IEMA

Illinois Emergency Management Agency

Bureau of Radiation Safety

Report on Environmental Monitoring for the Sheffield Low-Level Radioactive Waste Disposal Site for Calendar Year 2013

November 2014

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I. INTRODUCTION

The Sheffield Low-level Radioactive Waste (LLRW) disposal site is located approximately three miles southwest of the town of Sheffield in Bureau County, Illinois. The town of Sheffield is about 120 miles west-southwest of Chicago, situated approximately midway between Peoria and Moline/Rock Island, Illinois, just south of Interstate-80. The facility began disposing LLRW in 1967, and closed in 1978 after reaching capacity. The LLRW disposal site includes 3.2 million cubic feet of LLRW buried in 21 shallow earthen trenches on 20.4 acres.

The state of Illinois began conducting an environmental monitoring program at the LLRW site in 1967. Between 1967 and 1980, the program was conducted by the Illinois Department of Public Health (IDPH). Since October 1980, the Illinois Emergency Management Agency (IEMA; formerly the Illinois Department of Nuclear Safety (IDNS)) has managed the monitoring program. Results of monitoring conducted between 1967 and 1988 were reported by IDNS in February 1991 (IDNS 1991), and the results of monitoring during 1989 and 1990 were reported in June 1992 (IDNS 1992). The June 1992 report also described features of the site including meteorological and hydrological factors that control the concentrations of radioactive contaminants in ground water and surface water.

Of note, in 1976 radioactive contamination was observed in ground water in the southeast quadrant of the original 20.4-acre disposal site. As a result, ongoing studies of the geology and hydrology of the site were expanded by both the Illinois State Geological Survey (Heigold and Larson 1984) and the United States Geological Survey (USGS) (Foster et al. 1984). These studies were designed to determine the best approach for monitoring the movement of the radioactive contamination in the ground water.

Since disposal of LLRW took place in earthen trenches, the major monitoring effort has been directed toward detecting radioactive contamination of ground water. Samples are analyzed for a variety of radionuclides. These radionuclides may emit alpha particles, beta particles, and/or gamma rays. The type of radioactive emission determines the type of analysis required to detect a radionuclide.

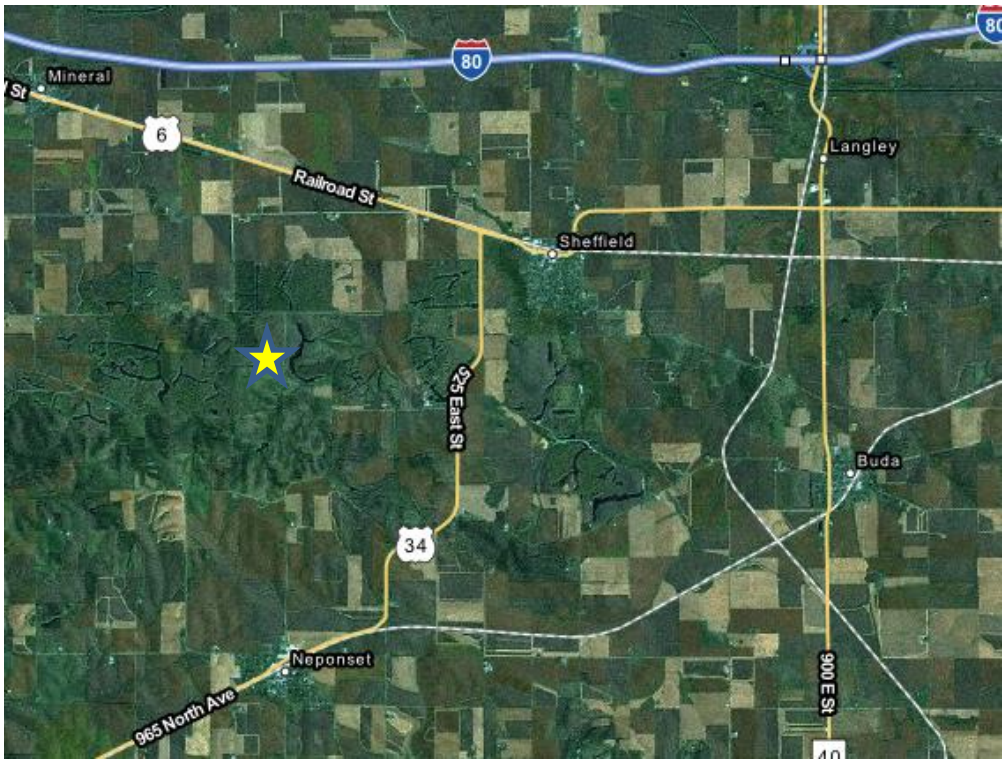
The performance of a LLRW site is measured by its ongoing ability to isolate the radioactive waste from the surrounding environment thus minimizing the potential for public exposure to radiation. The environmental monitoring program at Sheffield is designed to evaluate the site's performance as defined above by monitoring radionuclide movement, or lack thereof, away from the site and into pathways of possible human exposure.

The purpose of this report is to provide updated results of monitoring conducted during calendar year 2013; however, monitoring results from other time periods have been included for purposes of clarity or continuity. ***Since 1989, the level of contamination in the ground water as observed by the Agency has consistently decreased.***

II. DESCRIPTION OF THE SHEFFIELD LLRW DISPOSAL SITE

The Sheffield LLRW disposal site is located on rolling glaciated terrain in north-central Illinois approximately three miles southwest of the town of Sheffield. The location of the site is shown in Figure 1.

Figure 1. Location of Sheffield Low-Level Radioactive Waste Disposal Site
(Indicated by Yellow Star on the Map)



The area near the LLRW site is sparsely populated with less than 20 residences within a two mile radius. Sheffield, with a population of 926 (2010 Census), is three miles to the northeast. The unincorporated town of Mineral, population 237 (2010 Census), is five miles to the northwest; the town of Neponset, population 473 (2010 Census), is three miles south of the site.

The 20.4-acre disposal site contains 21 disposal trenches, varying from 8 to 25 feet deep. A 196-acre buffer zone surrounds the site and includes a small lake, called Trout Lake, and a small stream to the south and southeast. Trout Lake has previously been called Strip Mine Lake and Barbed Wire Lake. The facility was licensed to accept radioactive waste in August 1967, began disposing waste in 1968, and closed in 1978 after the shallow land burial trenches were filled with LLRW.

A precise inventory of LLRW buried in each trench was not kept by the site operator, but has been estimated in three separate studies (NUS 1979; Dragonette et al. 1979; MacKenzie et al. 1985). The estimated inventory of important radionuclides is listed in Table 1.

Table 1. Maximum Values Estimated in the Sheffield Inventory (Important Radionuclides with Half-Lives Greater than Five years)

Radionuclide	Curies	Half-Life (Years)
H-3	5,990	12.35
C-14	450	5,730
I-129	0.01	15,700,000
Sr-90	3,690	28.1
Cs-137	15,500	30
Co-60	20,000	5.27
Pu-238	7.5	87.74
Pu-239; Pu-240; Pu-241	4,870	24,065; 6,550; 14.4
Am-241	137.5	432

Two hazardous waste disposal areas are located to the north and northwest of the LLRW disposal site and are separated from it by at least 150 feet. These areas were used for the disposal of non-radioactive hazardous chemical waste. The first area accepted waste from 1968 to 1974 and the second area from 1974 to 1983.

The U.S. Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (IEPA) are the primary agencies responsible for regulation of the adjacent hazardous chemical waste sites. The site operator is working with USEPA and IEPA to remediate these sites and the surrounding area. IEMA is closely monitoring plans for site remediation to ensure that there are no potential adverse effects on the radioactive waste site.

As part of this remediation effort, a single set of samples were taking during 1988 by SAIC, a US Ecology contractor, and analyzed for radionuclides as well as chemical contaminants. The results of this set of samples indicated extensive contamination of ground water to the northeast of the LLRW site (SAIC 1988). Ground water in this area contains tritium (hydrogen-3 or H-3, is a weakly radioactive form of hydrogen and decays via beta emission) as well as a variety of chemical contaminants. Since tritium is chemically identical to non-radioactive hydrogen, it is readily assimilated into water (that is, one or both of the "H's" in H_2O can be tritium, a form called "tritiated water"). This causes tritium to be very mobile in the natural environment. Tritium's half-life is 12.3 years, which means it will persist in the environment for about 100 years.

III. HYDROLOGY OF THE SHEFFIELD LLRW DISPSAL SITE

The Sheffield LLRW site and its surrounding buffer zone are located on rolling glacial terrain in northwest central Illinois. The shallow local aquifer is comprised of saturated glacial sediments and is isolated from the deep regional aquifer by a 450-foot sequence of Pennsylvanian shale bedrock. The pizometric surface of the glacial aquifer generally conforms to topographic drainage systems, with gradients nominally trending west to east.

Northeast Pathway

The primary flow path for radiologically contaminated ground water begins in a pebbly sand deposit that exists under the northern two-thirds of the disposal site. This relatively permeable unit (Toulon Member of the Glasford Formation) extends to the northeast where it constricts, infilling a narrow outwash channel in the bedrock surface. This narrow channel, filled with deposits of saturated sand and gravel, extends from the northeast portion of the LLRW site to Trout Lake. Along the Lake's western shore, ground water can be observed as springs exiting the pebbly sand unit and entering the Lake. (See Figure C-2 in Appendix C.)

Because the northeast pathway is the principal route for contaminants leaving the LLRW site, considerable effort has gone toward understanding radionuclide movement in this area. Monitoring wells in this pathway include 563, 575, 577, and 600. The ground water in these wells emanates from the continuous deposit of relatively permeable sand and gravel that underlies the northern two-thirds of LLRW site. This deposit of coarse grained soils narrows and extends in a northeasterly direction terminating along the western shore of Trout Lake. The above-cited wells sample contaminated ground water as it moves through this narrow outwash channel from beneath the LLRW site toward and into Trout Lake.

Of the 100+ ground water monitoring wells throughout the entire buffer zone, the most highly contaminated are in the northeast pathway, principally 577, 563, 575, and 600. In the order listed, these wells extend along a line originating near the eastern edge of the LLRW site and extending about 900 feet in a northeasterly direction, terminating near Trout Lake. Tritium concentrations in these 4 wells were measured monthly or bimonthly from 1988 to 2012, and quarterly since 2012, resulting in an extensive data base spanning more than 25 years.

Southeast Pathway

A second ground water pathway extends from under the approximate southern one-third of the LLRW site into the valley to the south and southeast. Unlike the northeast pathway, there is no continuous, spatially concentrated deposit of relatively permeable, coarse grained soils in the southeast pathway. Because of this, ground water flow velocities and volumes are relatively reduced, lessening the potential for movement of significant quantities of radiological contamination away from the disposal site. Consequently, areas of contamination are less extensive and contaminant concentrations are about ten times less than those observed in the more permeable northeast pathway. Like the northeast pathway, the vast majority of radiological contamination moving along this pathway ultimately discharges into Trout Lake. (See Figure C-2 in Appendix C.)

Monitoring wells in this pathway include 512, 525, 567, 602, and TB. The most highly contaminated wells in this pathway are 512 and 525. These wells are located in the buffer zone, between the southeast corner of the LLRW site and the small stream located about 300 feet farther to the southeast. This pathway lacks the more permeable sand and gravel deposits of its northern counterpart. Due to equipment malfunctions during 2013, it was difficult to obtain samples from Well 512, or enough volume of sample to perform each type of analysis.

IV. SETTLEMENT AGREEMENT

In 1979, site operator US Ecology attempted to abandon the LLRW site, unilaterally terminating its US Nuclear Regulatory Commission and IDPH licenses and state lease. This led to investigations which revealed that there were faulty trench caps. Both state and federal regulators objected to the unilateral terminations, arguing that the site operator must first safely close the site before terminating either of the licenses. This resulted in both federal and state litigation. The federal litigation was administratively argued before the Atomic Safety and Licensing Board, which eventually ruled against the operator on all counts.

The state's complaint was argued before the Bureau County Circuit Court. After ten years of negotiations, in May 1988, the State of Illinois and US Ecology came to an agreement and the litigation was resolved in the form of a settlement agreement known as the Sheffield Agreed Order (Agreed Order).

The Agreed Order specified what the site operator must do to safely close the site and assure its continuing safety into the future. Provisions and consequences of the agreement have had a significant impact on the scope of the monitoring program. The closure plan for the site has four basic parts:

1) The operator agreed to install a new, low-permeability clay cap over all the waste trenches. The purpose of the cap is to significantly reduce the amount of radioactive material moving away from the site and thus reduce the potential for movement of radioactivity beyond the buffer zone.

2) The operator agreed to purchase a buffer zone around the site. The 170-acre buffer zone is designed to contain, delay and dilute any contaminants leaching from the waste so any discharges beyond the buffer zone are below limits for release into unrestricted areas. Fences surrounding this zone were to be installed and maintained by the operator.

3) The operator agreed to monitor and maintain the site and buffer zone until 1998. Also, US Ecology agreed to establish a long-term care fund to pay for IEMA (formerly IDNS) maintenance and monitoring beyond 1998.

4) If radionuclides are discovered outside the buffer zone in concentrations equal to or exceeding the limits for discharges to unrestricted areas (see Table 2), the operator must remedy the situation at its expense or pay the state an additional $1.9 million.

Table 2. Regulatory Limits in Water for Selected Radionuclides

Trigger / Regulatory Limits in Water for Selected Radionuclides Per the Settlement Agreement of 1988		
Radionuclide	**Half-Life**	**Limit in Water (picocuries per Liter)**
H-3 (Tritium)	12.35	3,000,000
C-14 (Carbon)	5,730	800,000
I-129 (Iodine)	15,700,000	60
Sr-90 (Strontium)	29.12	300
Cs-137 (Cesium)	30	20,000
Co-60 (Cobalt)	5.27	50,000
Pu-238 (Plutonium)	87.74	5,000
Pu-239 (Plutonium)	24,065	5,000
Am-241 (Americium)	432	4,000
From: *Title 32, Illinois Administrative Code, Chapter II, Section 340, Appendix A, Table II, Column 2,* "Concentration in Air and Water above Natural Background," January 1987, as found in the Illinois Department of Nuclear Safety, Environmental Monitoring Report Sheffield Low-Level Radioactive Waste Disposal Site 1989-1990.		

The new cap consists of 4.5 feet of highly compacted, low-permeability, clay covered with 6 inches of vegetated topsoil. Construction was completed in September 1989. The cap is designed to significantly reduce the amount of precipitation that can infiltrate the trenches and mobilize the waste. As part of the effort to install the cap, a number of onsite monitoring wells, sump risers, and piezometers adjacent to the waste trenches were sealed and are no longer accessible. The new cap and immediately surrounding area are inspected regularly by IEMA and US Ecology personnel for proper vegetative cover and evidence of erosion or burrowing animals. As part of the settlement agreement, the operator has committed to immediate repairs to damaged areas.

In 2008, IEMA had the cap civil surveyed to estimate if subsidence is occurring over the trench area, and to assess if precipitation will drain from the site or pond on the surface. The survey concluded subsidence, if any, was minimal and the cap is draining as expected. IEMA will have the cap resurveyed in 2015 to assess the cap's integrity.

In accordance with the Agreed Order, the company was required to meet specified financial conditions or post letters of credit. The company did not meet the financial tests and did not post the required letters of credit in either 1996 or 1997. In November 1997, the state brought suite in Bureau County to require the company to remain at the site and continue to provide site maintenance after May 1998 due to the company's breach of the Agreed Order. In April 1998, the Court ruled that the company was in breach of the agreement and could not turn the site over to the state in May 1998. The court encouraged the parties to settle remaining issues. The parties entered into an addendum to the 1988 agreement called the 1999 First Supplement, which requires the company to remain at the site until it satisfied the financial conditions in the agreement, modifies some site monitoring requirements, and provides for transfer of private insurance for the site. Pursuant to the First Supplement, U.S. Ecology satisfied all its financial conditions in June 2001 and at that time, the State took ownership of the

LLRW site. The state may take possession of the buffer zone at any time for a nominal fee, but must take ownership when the Agreed Order expires in May 2038.

In 1981, verifiable tritium was found offsite and off US Ecology property in well 563. This led to the idea of the buffer zone.

The Agreement Order defined terms that are only applicable to the Sheffield LLRW site, such as a "signaling event". A "signaling event" is defined as the occurrence within the Buffer Zone of any one of several events described in detail in the Agreed Order. In 1990, IDNS declared a "signaling event", because sampling and analyses detected that tritium had exited Trout Lake and the Buffer Zone Boundary. While the declaration of a signaling event does not indicate a threat to public health and safety, it serves as an official notice to the operator that events have occurred that may require attention and remedial action. One of the new objectives of the monitoring program is to collect sufficient data to determine whether signaling events are occurring.

In 1997, IEMA once again started litigation proceedings against US Ecology, this time for failure to comply with the Settlement Agreement. Specifically, US Ecology's parent company, American Ecology Corporation (AEC), did not meet the financial requirements as stipulated in the Settlement Agreement. In 1998, IEMA and US Ecology reached an out of court settlement, known as the First Supplement, which paved the way for transfer of the disposal site to IEMA following issuance of an audited annual financial statement of AEC showing that AEC did satisfy the financial standards. Such an audited annual financial statement was issued for 2000 and IEMA assumed ownership of the LLRW site in August 2001.

US Ecology remains responsible for certain remedial actions at the facility should any become necessary. The company's liability for such an occurrence is limited to $1.9 million and expires in 2038.

V. TRITIUM MIGRATION

With historical failure of the individual trench caps, subsidence, and water in the trenches, it could be expected that leachate migration might ensue. IDPH began monitoring the Sheffield site in 1967, and when the opportunity arose in the form of a study proposed by the Illinois State Geological Survey (ISGS) to evaluate possible migration from the non-radioactive chemical waste site to the west, IDPH requested that the study ascertain whether chemical pollution from the "old" chemical site had entered State land and whether horizontal migration of radioactive waste occurred in the disposal trenches. To no one's surprise, radioactive contamination was observed in the ground water. Tritium (a highly mobile form of radioactive hydrogen) was migrating across the site in concentrations that were measureable but well below levels considered to be a threat to public health. As a result of the discovery of migrating tritium, geology and hydrology studies were performed by both the Illinois State Geological Survey (Heigold and Larson, 1985) and the United States Geological Survey (Foster et al., 1984).

Since the LLRW site cap was installed, there has been a steady decline in the concentration of tritium in water samples, suggesting the cap is performing as designed. It appears no additional water has infiltrated the site, which would potentially result in an increase in radionuclides in the ground water samples. The graphs in Appendix A and B visually demonstrate this downward trend for on-site sample locations (Appendix A) and off-site sample locations (Appendix B).

VI. DESCRIPTION OF THE ENVIRONMENAL MONITORING PROGRAM

During 2013, the IEMA Environmental Monitoring program consisted of sample collection, sample analysis by the IEMA Radiochemistry Laboratory in Springfield, and data review and analysis of the results from the Laboratory. Sample collection includes obtaining samples from both on-site locations (including the site and the buffer zone around the site), and off-site locations (such as creeks and streams beyond the buffer zone, and Public Water Supplies in the area). A general description of sample collection and sample analysis follows, with results tables divided out between On-Site samples and Off-Site samples.

Sample Collection

- Surface water, drinking water and ground water are sampled on a regular basis. 259 samples were taken during calendar year 2013, which is representative of the average number of water samples taken annually. All samples are analyzed for gross alpha, gross beta and tritium concentrations. Samples with elevated alpha or beta concentrations are analyzed for specific gamma emitting radionuclides and for the beta emitting radionuclide strontium-90. Selected samples are also analyzed for the low-energy beta emitter carbon-14.

- Air particulate samples are collected continuously by a low-volume sampler near the cap, and are analyzed weekly for airborne radioactivity.

- Vegetation samples are collected annually and analyzed for radionuclides that may have been transported from the environment and incorporated into plant tissue.

- Sediment samples are collected semi-annually and analyzed for radionuclides that may have settled out of solution or suspension.

- Measurements of direct gamma radiation are collected and analyzed quarterly using optically-stimulated luminescent dosimeters (OSLs) placed around the LLRW site.

Laboratory Analysis

Samples were analyzed by the IEMA Radiochemistry Laboratory located in Springfield. The Laboratory participates in semi-annual proficiency testing programs through Environmental Resource Associates, an accredited proficiency testing provider.

The Laboratory uses standard published radioanalytical procedures. Since the radionuclides in the disposal trenches emit either alpha or beta particles, all environmental samples are analyzed for total

alpha and beta radioactivity. This provides a good method of screening samples for the presence of radioactive material. Tritium emits a beta particle, but its energy is too low to be detected by ordinary analytical methodologies for evaluating gross beta activity. To measure the concentration of tritium, all water samples are distilled and analyzed using liquid scintillation counting, a technique that is capable of measuring radioactive emissions at very low energies and very low concentrations.

At the Sheffield facility, carbon-14 movement tracks well with the movement of tritium. This means that the carbon-14 is likely organically bound (biologic/scintillation wastes) and/or in anionic species such as carbonates ($CO_3^{=}$) or bicarbonates (HCO_3^{-}). None of these carbonic forms is adsorbed readily onto soil particles and, like tritium, will move freely with ground water. Since carbon-14 occurs naturally in the environment along with other non-radioactive isotopes of carbon, the laboratory performs an analysis for total organic carbon as well as an analysis for this specific isotope. The Carbon-14 isotope emits a low-energy beta particle and is detected using liquid scintillation.

Annually, samples are analyzed for carbon-14, strontium-90, and gamma emitting radionuclides such as Cesium-137. Strontium-90 is easily masked by other radionuclides, including those which are naturally occurring. Therefore, these samples undergo preliminary chemical separation so strontium may be isolated for analysis. Gamma emitting radionuclides are analyzed using a high-purity germanium detector in a process called gamma spectroscopy, which allows the identification of individual radionuclides.

VI. INTERPRETING LABORATORY RESULTS

Each measurement technique has its own minimum detectable concentration (MDC) which is the smallest quantity of radioactive material per unit volume which can be detected reliably. The MDC is a function of the limitations of the nuclear counting equipment, the volume/weight of sample used, chemical separation techniques and ambient natural background radiation present in the laboratory. All analytical methods have limitations: amounts that are just too small to be detected. The Minimum Detectable Concentration (MDC) is an "a priori" measure of that limitation – an estimate of the lower limit of detection. It is defined as the smallest quantity that an analytical method has 95% likelihood of detecting. For example, the MDC for IEMA's method for tritium in water is 200 pCi/L.

Given a sample with a tritium concentration of 200 pCi/L, our laboratory would detect that tritium approximately 95 times out of 100. Samples with less than 200 pCi/L could be detected, but with less certainty. Conversely, samples with more than 200 pCi/L would be more likely to be detected, approaching 100% as concentrations increase.

Negative numbers in the tables of this report are the values reported by the IEMA Radiochemistry Laboratory. Each batch of samples is counted with a sample blank to determine a background for each analytical instrument and each type of medium being analyzed. That background reading is then subtracted from the analytical result. When the sample has very little radioactivity, subtracting background values may actually result in a negative number.

VII. ENVIRONMENTAL MONITORING RESULTS

The environmental monitoring program is designed to evaluate the environment in general and site performance in specific by monitoring the movement, or lack of movement, of radionuclides and subsequently determine any potential for public exposure to radionuclides. On-site and off-site monitoring locations are shown in Appendix C.

On-Site Ground Water Monitoring

Since the waste at the Sheffield facility is buried in shallow earthen trenches, the major emphasis of the environmental monitoring program involves the sampling and analysis of ground water. Although the new cap was constructed in 1989, the ground water travel time from the site to downstream monitoring wells is on the order of a few years (Garklavs and Toler, 1984). IEMA continues to monitor ground water through wells around the cap and in the buffer zone. As discussed in Section III, there are two major pathways of ground water flow from beneath the site. The primary flow path is from beneath the northern two-thirds of the site to the northeast; this is referred to as the "northeast pathway." The secondary flow path is from beneath the southern one-third of the site to the south and southeast; this is known as the "southeast pathway." The vast majority of ground water in both pathways eventually discharges into Trout Lake, which in turn, supplies both ground water and surface water to down gradient areas beyond the buffer zone. The area immediately down gradient from the buffer zone boundary is where "point-of-compliance" monitoring occurs because it is here that radionuclide concentrations can compared to regulatory limits for discharges to unrestricted areas.

Considerable effort has gone toward describing radionuclide concentrations in the northeast pathway wells. Before the site was recapped, the factors which influenced these concentrations were:

- Precipitation on the disposal site;
- Condition of the trench caps during this precipitation; and
- Precipitation in other areas which also recharged the pathway wells.

These factors worked interdependently to affect concentrations observed at a given time in each well. Variations in precipitation on the LLRW disposal site resulted in variable amounts of moisture available for transport of tritium. When tritium was transported to ground water in the vicinity of a monitoring well, it was diluted by local precipitation. When combined, these variables resulted in a cyclical pattern of tritium concentrations in many of the northeast pathway wells. Since the installation of the new cap, it is expected that the leaching of contamination from the trenches will be minimized, and that the vast majority of contamination reaching the monitoring wells was in the saturated zone prior to the installation of the new cap. The only remaining factor which drives changes in contaminant concentration in monitoring wells is the precipitation in areas which recharge the wells. Table 3 shows Gross Alpha/Beta screening results for on-site ground water samples (and the on-site lunchroom tap).

Table 3. Gross Alpha/Beta Screening Results for On-Site Ground Water Samples
Results are in picocuries per Liter (pCi/L)

Quarter	Location Description	Results		Error		MDC	
		Alpha	Beta	Alpha	Beta	Alpha	Beta
Quarter 1	Chem Site Well 150	-0.2	3.0	1.1	2.1	1.8	3.5
	Lunchroom Tap	0.9	4.7	1.3	2.3	2.1	3.7
	USEC Well H	0.2	2.6	1.1	2.1	1.8	3.5
	USGS Well 511	5.2	2.8	2.7	4.6	3.9	7.7
	USGS Well 512	-0.3	6.7	1.1	2.2	1.8	3.5
	USGS Well 513	-1.1	1.2	1.2	2.2	2.1	3.7
	USGS Well 515	-0.3	2.8	1.3	2.2	2.1	3.7
	USGS Well 516	-0.2	2.2	1.1	2.1	1.8	3.5
	USGS Well 563	3.0	6.6	1.3	2.2	1.8	3.5
	USGS Well 567	1.8	5.3	1.2	2.2	1.8	3.5
	USGS Well 575	2.8	4.7	1.2	2.2	1.8	3.5
	USGS Well 600	4.1	3.3	1.3	2.1	1.8	3.5
	USGS Well 602	1.0	7.2	1.2	2.2	1.8	3.5
	USGS Well TB	1.3	3.2	1.4	2.2	2.1	3.7
Quarter 2	Chem Site Well 150	1.0	0.9	1.2	2.2	1.8	3.7
	Lunchroom Tap	2.0	4.1	1.2	2.3	1.8	3.7
	USEC Well H	-0.5	1.8	1.1	2.2	1.8	3.7
	USGS Wel 511	1.8	1.1	1.3	2.2	2.0	3.8
	USGS Well 512	-1.0	1.7	1.1	2.4	1.9	4.0
	USGS Well 513	-0.1	1.5	1.2	2.3	2.0	3.8
	USGS Well 515	-0.8	1.0	1.2	2.2	2.0	3.8
	USGS Well 516	-1.3	1.6	1.1	2.3	2.0	3.8
	USGS Well 563	1.4	3.5	1.3	2.3	2.0	3.8
	USGS Well 567	0.3	3.4	1.2	2.3	2.0	3.8
	USGS Well 575	2.2	5.9	1.3	2.4	2.0	3.8
	USGS Well 577	2.2	6.9	1.3	2.4	2.0	3.8
	USGS Well 600	4.5	2.2	1.4	2.3	2.0	3.8
	USGS Well 602	-0.1	6.5	1.1	2.4	1.8	3.7
	USGS Well TB	0.7	0.4	1.2	2.2	1.8	3.7
Quarter 3	Chem Site Well 150	-0.5	1.5	1.3	2.5	2.1	4.2
	Lunchroom Tap	1.9	6.5	1.4	2.5	2.0	3.9
	USEC Well H	0.6	2.3	1.3	2.5	2.1	4.2
	USGS Wel 511	1.5	4.2	1.3	2.4	2.0	3.9
	USGS Well 513	-0.2	1.3	1.3	2.3	2.0	3.9
	USGS Well 515	-0.2	-0.1	1.3	2.3	2.0	3.9
	USGS Well 516	-0.2	0.7	1.3	2.3	2.0	3.9
	USGS Well 525	0.1	2.4	1.3	2.4	2.0	3.9
	USGS Well 563	2.2	5.7	1.4	2.4	2.0	3.9
	USGS Well 567	1.7	2.7	1.4	2.4	2.0	3.9
	USGS Well 575	2.8	5.6	1.4	2.4	2.0	3.9
	USGS Well 577	3.7	4.0	1.4	2.4	2.0	3.9
	USGS Well 600	6.3	3.3	1.5	2.4	2.0	3.9
	USGS Well 602	0.3	6.7	1.3	2.5	2.0	3.9
	USGS Well TB	0.6	-0.9	1.3	2.4	2.1	4.2

Quarter	Location Description	Results		Error		MDC	
		Alpha	Beta	Alpha	Beta	Alpha	Beta
Quarter 4	Chem Site Well 150	0.7	0.5	1.4	2.3	2.1	3.9
	Lunchroom Tap	1.4	1.8	1.4	2.4	2.1	3.9
	USEC Well H	-0.7	-0.4	1.3	2.3	2.1	3.9
	USGS Wel 511	2.4	0.0	1.4	2.3	2.1	3.9
	USGS Well 513	0.1	0.7	1.3	2.3	2.1	3.9
	USGS Well 515	0.2	-0.5	1.3	2.3	2.1	3.9
	USGS Well 516	0.5	0.2	1.3	2.3	2.1	3.9
	USGS Well 525	0.9	0.6	1.4	2.5	2.1	4.3
	USGS Well 563	2.3	8.4	1.4	2.5	2.1	3.9
	USGS Well 567	3.3	0.7	1.5	2.5	2.1	4.3
	USGS Well 575	4.5	6.9	1.5	2.7	2.1	4.3
	USGS Well 577	5.5	10.0	1.6	2.7	2.1	4.3
	USGS Well 600	5.0	2.0	1.6	2.6	2.1	4.3
	USGS Well 602	1.8	3.5	1.4	2.6	2.1	4.3
	USGS Well TB	2.7	-1.1	1.4	2.3	2.1	3.9

Table 4 (below) shows tritium results for samples taken during calendar year 2013. For additional perspective, Appendix A depicts tritium (H-3) results at the same on-site sampling locations, and Appendix B depicts tritium (H-3) results for off-site sampling locations. The graphs include historical results for those sites, including "error bars" relating to the error, or uncertainty for each result. The historical data is included to demonstrate the gradual decrease in the concentration of tritium in these wells over time. In addition, the graphs show that the highest recorded tritium concentration is below some percentage of the Regulatory Limit of 3,000,000 picocuries per Liter (pCi/L).

Table 4. Tritium (H-3) Results for On-Site Ground Water Samples
Results are in picocuries per Liter (pCi/L)

Quarter	Location Description	Results	Error	MDC
Quarter 1	Chem Site Well 150	-35.2	99.1	168
	Lunchroom Tap	-57.2	98.7	168
	USEC Well H	275	105	168
	USGS Well 511	-21.7	176.9	299
	USGS Well 512	5320	180	168
	USGS Well 513	36.9	68.9	114
	USGS Well 515	-17.6	99.5	168
	USGS Well 516	-28.5	99	167
	USGS Well 563	38500	416	168
	USGS Well 567	1470	127	168
	USGS Well 575	38800	417	168
	USGS Well 600	9910	228	168
	USGS Well 602	10600	234	167
	USGS Well TB	3610	159	168

Quarter	Location Description	Results	Error	MDC
Quarter 2	Chem Site Well 150	6.88	70.3	118
	Lunchroom Tap	4.35	67.4	113
	USEC Well H	308	76.6	114
	USGS Well 511	-26	66.9	114
	USGS Well 512	5730	169	113
	USGS Well 513	109	70.6	113
	USGS Well 515	-34.8	66.2	113
	USGS Well 516	-6.53	67.1	113
	USGS Well 563	26300	338	113
	USGS Well 567	1520	104	113
	USGS Well 575	39900	414	113
	USGS Well 577	33400	380	113
	USGS Well 600	7330	188	113
	USGS Well 602	8160	202	118
	USGS Well TB	1690	111	118
Quarter 3	Chem Site Well 150	0	78.2	132
	Lunchroom Tap	-23	110	185
	USEC Well H	342	86.9	132
	USGS Well 511	30.7	79.1	132
	USGS Well 513	-28.5	77.5	132
	USGS Well 515	13.2	78.7	132
	USGS Well 516	30.7	79.1	132
	USGS Well 525	487	90.5	132
	USGS Well 563	32800	380	132
	USGS Well 567	1620	114	132
	USGS Well 575	42700	431	132
	USGS Well 577	53100	479	132
	USGS Well 600	15400	266	132
	USGS Well 602	6740	186	132
	USGS Well TB	2020	121	132
Quarter 4	Chem Site Well 150	70	80	131
	Lunchroom Tap	-4.38	78.1	131
	USEC Well H	337	86.7	131
	USGS Well 511	-10.9	77.8	131
	USGS Well 513	4.37	78.2	131
	USGS Well 515	28.5	78.9	131
	USGS Well 516	61.3	79.8	131
	USGS Well 525	457	89.6	131
	USGS Well 563	29800	362	131
	USGS Well 567	1730	116	131
	USGS Well 575	36800	401	131
	USGS Well 577	45600	445	131
	USGS Well 600	17800	284	131
	USGS Well 602	6190	179	131
	USGS Well TB	1970	120	131

In addition to analyzing water samples for tritium quarterly, on an annual basis IEMA analyzes all water samples for Carbon-14, Strontium-90, Cs-137 and other gamma-emitting radionuclides. These radionuclides were chosen for annual monitoring because they represent those radionuclides with the highest abundance in the estimated inventory (see Table 1), but historically have very low concentrations in pathways. Due to the low concentrations, it has been determined annual sampling is sufficient to ascertain if these radionuclides are moving into the ground water. Table 5 contains results of other radionuclide analyses for all on-site sampling locations.

Table 5. Additional Radionuclide Results for All On-Site Water Samples
Results are in picocuries per Liter (pCi/L)

Location	Results				Error				MDC			
	C-14	Co-60	Cs-137	Strontium	C-14	Co-60	Cs-137	Strontium	C-14	Co-60	Cs-137	Strontium
Chem Site Well 150	34.0	0.1	0.3	0.7	21.9	1.1	1.1	0.6	28.5	3.2	3.2	0.9
Lunchroom Tap	0.2	-1.5	-1.1	0.1	20.8	1.3	1.1	0.5	28.5	3.2	3.1	0.9
S. Stream-merging with cap runoff	-28.2	0.7	0.9	-0.6	37.4	1.3	1.2	0.7	52.2	3.7	3.7	1.3
Trout Lake C	32.8	0.9	0.7	0.3	38.8	1.0	1.1	0.6	52.2	3.2	3.3	1.0
Trout Lake D	59.0	-0.4	0.1	0.2	30.8	1.1	0.9	0.6	39.3	3.0	2.8	1.0
USGS Well 511	1370.0	-0.5	-0.1	0.3	61.5	1.3	1.2	0.6	39.3	3.4	3.4	0.9
USGS Well 512	529.5				44.3				39.3			
USGS Well 513	28.8	-1.3	-1.7	-0.3	21.8	1.5	1.3	0.6	28.5	3.7	3.5	1.1
USGS Well 515	18.0	1.7	0.4	1.0	21.4	1.0	1.0	0.7	28.5	3.2	3.0	0.9
USGS Well 516	1.4	0.9	-1.9	-0.6	38.1	1.0	1.0	0.7	52.2	3.1	2.9	1.3
USGS Well 563	4357.1	0.6	-1.5	0.2	101.1	1.1	1.1	0.6	39.3	3.3	3.0	1.0
USGS Well 567	302.9	-2.1	-2.5	-0.7	38.4	1.5	1.4	0.8	39.3	3.6	3.8	1.5
USGS Well 575	1392.2	0.3	-2.4	-0.9	61.9	1.2	1.1	0.6	39.3	3.7	3.2	1.2
USGS Well 600	146.4	-2.1	-0.8	0.1	41.4	1.6	1.2	0.7	52.2	3.9	3.5	1.2
USGS Well 602	45.1	-0.1	-0.2	0.0	39.1	1.4	1.4	0.5	52.2	3.8	4.1	0.9
USGS Well TB	716.6	0.1	-0.9	0.3	38.5	1.4	1.2	0.6	28.5	4.0	3.5	0.9

On-Site Surface Water Monitoring

Samples also are taken from three different locations in Trout Lake (Shown in Appendix C) and an on-site stream on a regular basis. No evidence of alpha or beta contamination was detected in the lake. Gross alpha and beta results from Surface Waters (Trout Lake and an on-site stream) are listed in Table 6.

Table 6. Gross Alpha/Beta Screening Results for On-Site Surface Water Samples
Results are in picocuries per Liter (pCi/L)

Quarter	Location Description	Results		Error		MDC	
		Alpha	Beta	Alpha	Beta	Alpha	Beta
Quarter 1	S. Stream-merging with cap runoff	-0.1	4.3	1.1	2.1	1.8	3.5
	Trout Lake C	1.2	5.0	1.2	2.2	1.8	3.5
	Trout Lake D	0.5	6.5	1.1	2.2	1.8	3.5
Quarter 2	S. Stream-merging with cap runoff	-0.6	1.0	1.1	2.2	1.8	3.7
	Trout Lake A	1.3	6.5	1.2	2.4	1.8	3.7
	Trout Lake C	1.7	7.4	1.2	2.4	1.8	3.7
	Trout Lake D	1.6	6.8	1.2	2.4	1.8	3.7
Quarter 3	Trout Lake A	2.2	8.9	1.4	2.5	2.0	3.9
	Trout Lake C	1.7	7.0	1.4	2.5	2.0	3.9
	Trout Lake D	1.8	9.3	1.4	2.5	2.0	3.9
Quarter 4	S. Stream-merging with cap runoff	0.9	2.0	1.4	2.4	2.1	3.9
	Trout Lake A	0.9	5.2	1.4	2.4	2.1	3.9
	Trout Lake C	-0.3	8.2	1.3	2.5	2.1	3.9
	Trout Lake D	0.7	8.8	1.4	2.5	2.1	3.9

Tritium results for Trout Lake and the small on-site stream are listed in Table 7, and concentrations at the different sampling locations appear to depend on the following variables:

- Concentration of water from the springs;
- Amount of runoff from surrounding areas;
- Volume, if any, of lake discharge to the Lawson Creek tributary; and
- Presence or amount of ice on the lake.

Table 7. Tritium (H-3) Results from On-Site Surface Water Samples
Results are in picocuries per Liter (pCi/L)

Quarter	Location Description	Result	Error	MDC
Quarter 1	S. Stream-merging with cap runoff	103	102	168
	Trout Lake C	783	115	167
	Trout Lake D	653	113	168
Quarter 2	S. Stream-merging with cap runoff	60.7	69.6	114
	Trout Lake A	662	85.7	114
	Trout Lake C	664	85.8	114
	Trout Lake D	603	84.3	114
Quarter 3	Trout Lake A	574	92.5	132
	Trout Lake C	651	94.2	132
	Trout Lake D	576	121	185
Quarter 4	S. Stream-merging with cap runoff	15.3	78.6	131
	Trout Lake A	628	93.6	131
	Trout Lake C	744	96.1	131
	Trout Lake D	692	95	131

Effluent from Trout Lake flows along an unnamed tributary of Lawson Creek to the creek itself. From there, flow is into Abbott Ditch. See Appendix C for the relative location of Lawson Creek. Lawson Creek monitoring results are important because they represent the only contaminated surface water flow path crossing the buffer zone boundary. Results from sampling during 2013 in Table 8 below show no significant quantity of tritium crossing from the Sheffield site into off-site waters.

Table 8. Tritium (H-3) Results from Off-Site Water Results
Results are in picocuries per Liter (pCi/L)

Quarter	Location Description	Result	Error	MDC
Quarter 1	L. Farm Wells W	-19.7	99.2	167
	Lawson Creek	34.7	68.8	114
	PWS Mineral	-37.3	98.8	167
	PWS Neponset	-24.1	99.1	167
	PWS Sheffield	-32.9	98.9	167
Quarter 2	Hossetter Lake	-11.5	69.7	118
	L. Farm Wells W	13	68.2	114
	Lawson Creek	26.1	68	113
	PWS Mineral	-19.6	66.6	113
	PWS Neponset	17.4	67.8	113
	PWS Pencock Hill	-10.9	66.9	113
	PWS Sheffield	10.9	67.6	113
Quarter 3	Hossetter Lake	-15.3	77.9	132
	L. Farm Wells W	-6.91	110	185
	Lawson Creek	32.3	111	185
	PWS Mineral	-2.3	110	185
	PWS Neponset	-89.9	108	185
	PWS Pencock Hill	19.7	78.6	131
	PWS Sheffield	-2.3	110	185
Quarter 4	L. Farm Wells W	108	112	185
	Lawson Creek	-6.9	110	185
	PWS Mineral	-11.5	110	185
	PWS Neponset	-23	109	185
	PWS Pencock Hill	-80.6	108	185
	PWS Sheffield	9.21	110	185

Off-Site Sampling - Private Wells and Public Water Supplies

Drinking water samples are taken from offsite locations in the Sheffield area to assure that there is no impact in local water supplies. The Public Water Supplies (PWS) limits for radionuclides are based upon the USEPA and IEPA drinking water standards. Appendix B includes tables of historical data for tritium concentrations in off-site sampling locations, and the graphs show that the highest recorded concentration is below some percentage of the drinking water standard for tritium of 20,000 picocuries per Liter (pCi/L). The following offsite locations are sampled on a regular basis:

- L. Farm well
- Neponset public water
- Sheffield public water system
- Mineral public water system
- Pencock Hill water system

Results from sampling these water supplies indicate only naturally occurring radionuclides are present. None of the water supplies show radionuclides attributable to activities at the LLRW disposal site. Gross alpha/beta screening results for public water supplies appear in Table 9. The locations of these sampling points are shown in Appendix C.

Table 9. Sheffield Off-Site Gross Alpha/Beta Screening Results
Results are in microcuries per gram (uCi/g)

Quarter	Location Description	Results		Error		MDC	
		Alpha	Beta	Alpha	Beta	Alpha	Beta
Quarter 1	L. Farm Wells W	1.5	5.9	1.2	2.2	1.8	3.5
	Lawson Creek	0.2	5.0	1.3	2.3	2.1	3.7
	PWS Mineral	2.9	7.4	1.3	2.2	1.8	3.5
	PWS Neponset	3.3	12.2	1.3	2.4	1.8	3.5
	PWS Sheffield	0.8	5.8	1.1	2.2	1.8	3.5
Quarter 2	Hossetter Lake	1.2	2.2	1.2	2.2	1.8	3.7
	L. Farm Wells W	1.5	17.8	1.2	2.6	1.8	3.7
	Lawson Creek	1.4	3.0	1.2	2.3	1.8	3.7
	PWS Mineral	4.2	5.0	1.3	2.3	1.8	3.7
	PWS Neponset	4.0	7.7	1.3	2.4	1.8	3.7
	PWS Pencock Hill	3.7	5.5	1.3	2.2	1.8	3.5
	PWS Sheffield	-0.3	6.0	1.1	2.3	1.8	3.7
Quarter 3	Hossetter Lake	1.2	6.1	1.3	2.5	2.0	3.9
	L. Farm Wells W	2.9	5.8	1.4	2.4	2.0	3.9
	Lawson Creek	1.7	2.0	1.3	2.4	2.0	3.9
	PWS Mineral	2.8	7.6	1.6	2.7	2.4	4.4
	PWS Neponset	3.0	8.9	1.7	2.8	2.4	4.4
	PWS Pencock Hill	3.6	7.2	1.5	2.6	2.1	4.2
	PWS Sheffield	0.2	3.4	1.5	2.7	2.4	4.4
Quarter 4	L. Farm Wells W	3.7	7.2	1.5	2.7	2.1	4.3
	Lawson Creek	2.1	2.2	1.4	2.6	2.1	4.3
	PWS Mineral	2.8	5.7	1.5	2.7	2.1	4.3
	PWS Neponset	3.2	9.2	1.5	2.7	2.1	4.3
	PWS Pencock Hill	4.9	7.0	1.6	2.7	2.1	4.3
	PWS Sheffield	1.0	6.6	1.4	2.7	2.1	4.3

As stated for the on-site samples, IEMA also analyzes all water samples for Carbon-14, Strontium-90, and other gamma-emitting radionuclides, such as Cesium-137 on an annual basis. These radionuclides were chosen for annual monitoring because they represent those radionuclides with the highest abundance in the estimated inventory (see Table 1), but historically not found in off-site sampling locations. Table 10 contains results of other radionuclide analyses for all off-site sampling locations.

Table 10. Additional Radionuclide Results for All Off-Site Water Samples
Results are in picocuries per Liter (pCi/L)

Location	Results				Error				MDC			
	C-14	Co-60	Cs-137	Strontium	C-14	Co-60	Cs-137	Strontium	C-14	Co-60	Cs-137	Strontium
L. Farm Wells W	-36.8	1.2	-0.8	0.3	37.2	1.8	1.7	0.8	52.2	3.0	2.6	1.2
Lawson Creek	-23.8	-2.0	-0.9	-0.1	19.9	1.1	1.1	0.6	28.5	2.7	3.2	1.0
PWS Mineral	-50.6	0.0	0.7	0.2	36.8	1.2	1.0	0.6	52.2	3.4	3.2	0.9
PWS Neponset	7.2	0.6	-0.8	0.6	38.2	1.0	1.1	0.6	52.2	3.0	3.1	0.9
PWS Sheffield	-53.5	1.6	-0.7	-0.1	36.7	1.7	1.8	0.5	52.2	2.8	2.7	0.9

Air Monitoring

An air monitoring station is located near the northeast quadrant of the site. This sampler continuously collects particulates on glass fiber filters. Filters are analyzed weekly for gross alpha and beta activity. Results vary seasonally, but compare well with other control locations within the state. None of the sampling results indicate any airborne particulate releases from LLRW disposal site. Table 11 contains results of air sampling from the site.

Table 11. Air Monitoring Results
Results are in femtocuries per cubic meter (fCi/m^3)

Date	Alpha			Beta		
	Result	Error	MDC	Result	Error	MDC
1/7/2013	0.6	0.7	1.3	48.9	2.8	2.7
1/14/2013	3.2	1.0	1.3	40.5	2.6	2.6
1/21/2013	1.2	0.8	1.4	19.0	2.0	2.7
1/28/2013	3.3	1.0	1.3	42.7	2.7	2.7
2/4/2013	1.6	0.8	1.3	33.0	2.4	2.7
2/11/2013	0.7	0.7	1.3	26.4	2.2	2.6
2/19/2013	1.2	0.7	1.1	29.1	2.2	2.4
2/25/2013	0.8	0.8	1.4	22.6	2.7	4.2
3/4/2013	0.5	0.6	1.3	13.9	2.1	3.6
3/11/2013	1.6	0.7	1.2	14.6	1.8	2.7
3/18/2013	1.7	0.8	1.2	20.7	2.0	2.7
3/25/2013	1.2	0.7	1.2	25.5	2.2	2.6
4/1/2013	1.6	0.8	1.3	15.1	2.2	3.7
4/8/2013	2.4	0.9	1.3	22.4	2.5	3.8
4/15/2013	0.8	0.7	1.2	11.5	2.1	3.7
4/22/2013	2.1	0.9	1.3	11.4	1.8	2.8
4/29/2013	3.8	1.0	1.4	16.2	2.0	2.9
5/7/2013	1.2	0.7	1.2	20.4	2.2	3.3
5/13/2013	1.2	0.8	1.5	13.0	2.0	3.1
5/20/2013	1.2	0.8	1.3	30.4	2.4	2.7
5/29/2013	2.2	0.7	1.1	12.6	1.8	2.9
6/3/2013	1.4	1.0	2.0	12.9	2.8	5.3
6/10/2013	2.0	0.9	1.4	12.5	1.8	2.7

Date	Alpha			Beta		
	Result	Error	MDC	Result	Error	MDC
6/17/2013	2.9	1.2	2.0	27.0	2.9	3.9
6/28/2013	3.3	0.9	1.2	25.9	2.5	3.6
7/1/2013	4.5	1.8	2.7	12.6	4.2	8.2
7/8/2013	3.8	1.0	1.3	18.9	2.1	2.9
7/15/2013	0.8	0.7	1.4	22.4	2.2	2.9
7/22/2013	1.3	0.7	1.3	19.8	2.1	2.8
7/30/2013	0.9	0.6	1.0	16.2	1.9	3.0
8/5/2013	2.6	1.0	1.6	22.0	2.6	4.2
8/12/2013	2.9	0.9	1.3	29.1	2.5	3.5
8/19/2013	2.3	0.8	1.3	23.0	2.3	3.5
8/26/2013	3.0	1.0	1.4	36.7	2.6	3.4
9/3/2013	1.3	0.8	1.2	22.8	2.1	3.0
9/10/2013	1.9	0.8	1.2	42.2	2.9	3.5
9/16/2013	0.4	0.8	1.6	23.0	2.5	3.8
9/23/2013	1.6	0.7	1.1	27.7	2.4	3.3
10/1/2013	1.4	0.7	1.2	27.6	2.2	3.0
10/7/2013	1.7	1.0	1.7	19.1	2.6	4.1
10/14/2013	1.1	0.7	1.4	21.3	2.3	3.5
10/21/2013	1.1	0.7	1.3	21.0	2.3	3.5
10/28/2013	0.2	0.8	1.5	9.0	2.0	3.5
11/4/2013	2.4	0.9	1.3	35.4	2.6	3.4
11/11/2013	1.9	0.8	1.3	24.3	2.3	3.4
11/18/2013	2.5	0.9	1.3	25.5	2.4	3.5
11/25/2013	0.8	0.7	1.4	14.6	2.1	3.5
12/2/2013	1.6	0.7	1.3	28.7	2.2	2.5
12/9/2013	3.1	0.9	1.3	24.3	2.1	2.5
12/16/2013	3.3	1.1	1.6	41.7	2.8	3.5
12/23/2013	1.7	0.9	1.6	19.5	2.3	3.6
12/30/2013	4.4	1.2	1.5	34.4	2.7	3.6

Direct Radiation

Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. The dosimeters are arrayed around the perimeter of the Sheffield site and are exchanged and analyzed quarterly. IEMA performs the analysis of the dosimeters at the Springfield Laboratory location. The dosimeters are used to monitor for small changes in ambient background levels of gamma radiation that could result from releases of radioactive material.

Table 12 shows results for environmental dosimeters analyzed during 2013. In addition to the quarterly results, which are expressed as the average millirem per day, we have used those results to calculate the approximate millirem per year that would have been accrued by an individual at that location for an entire year. Those numbers can be compared to the average radiation exposure to an individual of 620 millirem per year from various sources (according to the 2009 National Council on

Radiation Protection's Report). Approximately 8% of that exposure is from Terrestrial and Cosmic radiation (background radiation), and equals approximately 49.6 millirem per year.

Table 12. Summary of Ambient Gamma Results

Location	Quarter 1 mRem/day	Quarter 2 mRem/day	Quarter 3 mRem/day	Quarter 4 mRem/day	Annual Dose mRem/year
SHER-01	0.12	0.14	0.13	0.17	50.19
SHER-02	0.10	0.10	0.13	0.11	39.97
SHER-03	0.13	0.14	0.11	0.16	48.82
SHER-04	0.12	0.12	0.15	0.17	51.47
SHER-05	0.13	0.15	0.15	0.14	50.92
SHER-06	0.14	0.14	0.15	0.16	54.02
SHER-07	0.12	0.14	0.15	0.14	49.28
SHER-08	0.11	0.12	0.13	0.12	43.62
SHER-09	0.09	0.11	0.11	0.11	37.87
SHER-10	0.13	0.13	0.15	0.16	51.83
SHER-11	0.12	0.11	0.12	0.12	43.16
SHER-12	0.10	0.13	0.15	0.16	49.37
SHER-13	0.11	0.13	0.12	0.13	44.44

On-Site Vegetation Sampling

Vegetation samples are taken to determine the degree of any bioaccumulation of radionuclides. A composite sample was taken from the cap during the monitoring period. All vegetation samples typically contain naturally occurring potassium-40 (K-40). Sampling results are shown in Table 13.

Table 13. Vegetation Sampling Results
Results are in microcuries per kilogram (uCi/kg)

Location	Date	Nuclide	Result	Error	MDC
Sheffield Cap	6/7/2013	CO-60	0.0	0.0	0.0
Sheffield Cap	6/7/2013	CS-137	0.0	0.0	0.0
Sheffield Cap	6/7/2013	K-40	31.5	0.8	0.5

Sediment Sampling

Samples of sediment are taken to determine whether contaminants previously in solution or suspension have settled out of a body of water. Such contaminants are not identified by water sampling. Sediment sampling results for sediment from Trout Lake and South Creek (on-site) are shown in Table 14, while sediment sample results from Lawson Creek (off-site) are shown in Table 15.

Table 14. Sheffield On-Site Sediment Sampling Results
Results are in microcuries per gram (uCi/g)

Location	Date	Nuclide	Result	Error	MDC
Stream S. of Site	June 2013	CO-60	0.0	0.0	0.0
Stream S. of Site	June 2013	CS-137	0.0	0.0	0.0
Trout Lake D	June 2013	CO-60	0.0	0.0	0.0
Trout Lake D	June 2013	CS-137	0.1	0.0	0.0
Stream S. of Site	Dec. 2013	CO-60	0.0	0.0	0.0
Stream S. of Site	Dec. 2013	CS-137	0.0	0.0	0.0
Trout Lake D	Dec. 2013	CO-60	0.0	0.0	0.0
Trout Lake D	Dec. 2013	Cs-137	0.0	0.0	0.0

Table 15. Sheffield Off-Site Sediment Sampling Results
Results are in microcuries per gram (uCi/g)

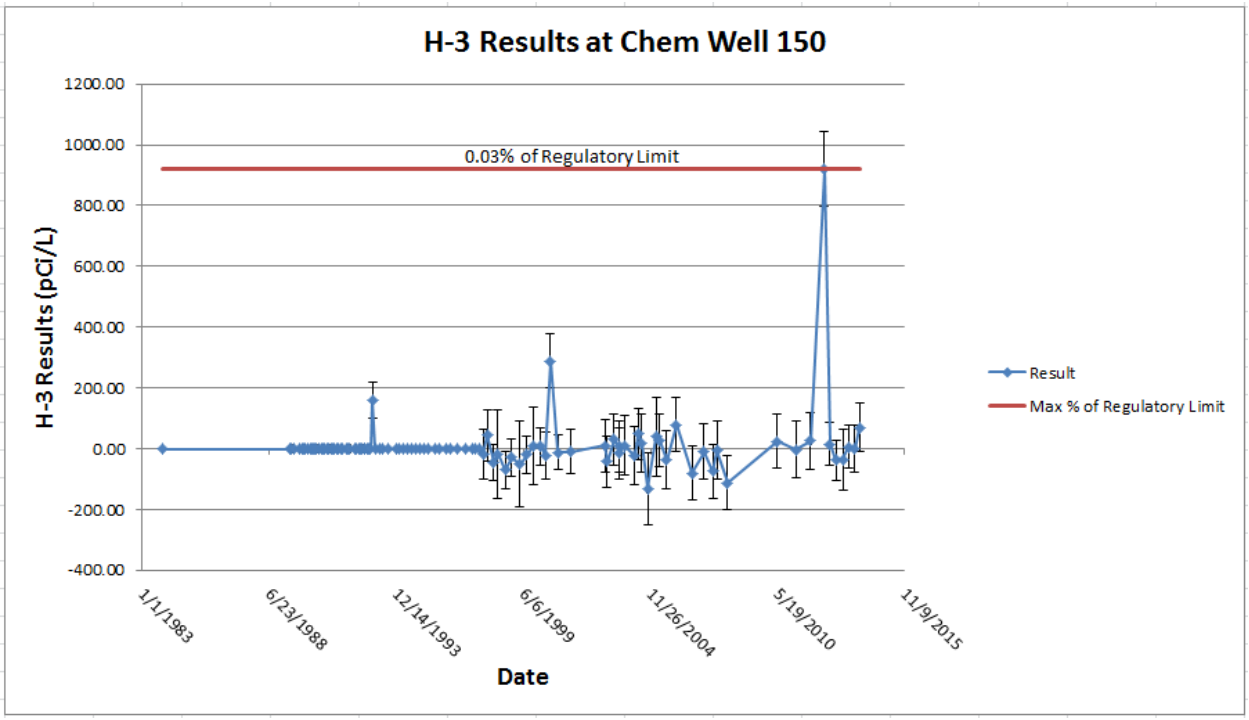
Location	Date	Nuclide	Result	Error	MDC
Lawson Creek	June 2013	CO-60	0.0	0.0	0.0
Lawson Creek	June 2013	CS-137	0.0	0.0	0.0

VII. SUMMARY

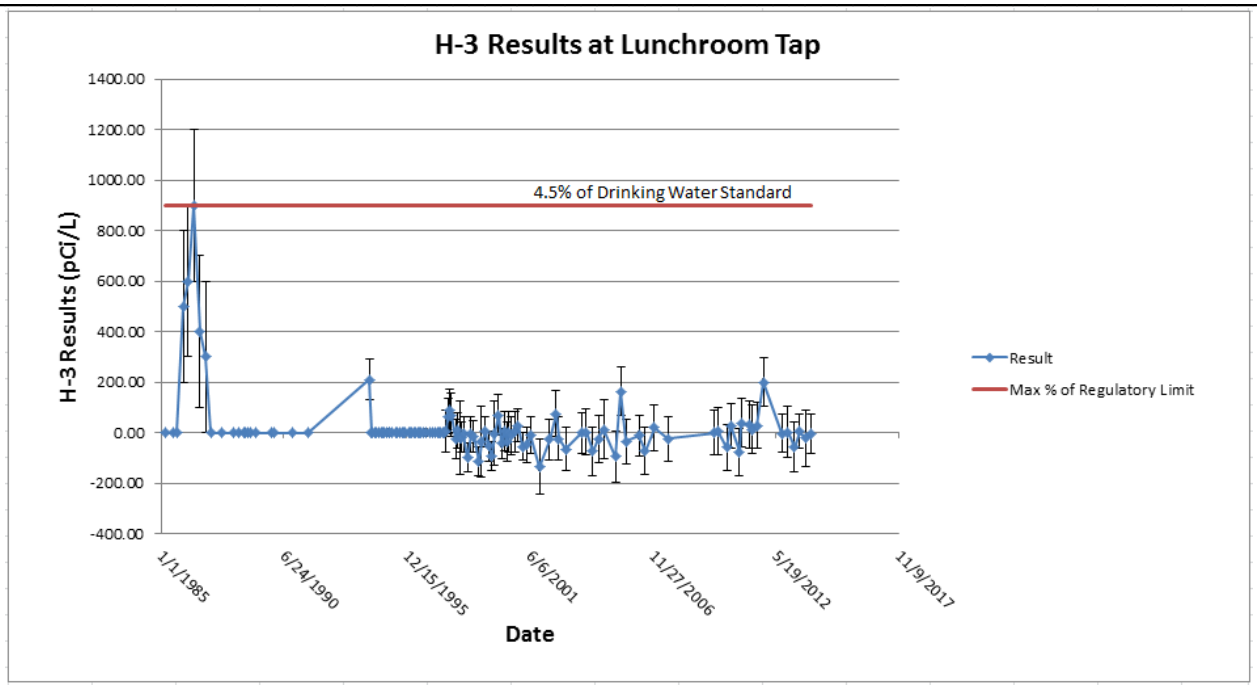
Contaminants from LLRW operations are observed in ground water moving in two narrow pathways from the site. The primary pathway extends to the northeast and terminates in Trout Lake. The secondary pathway travels to the southeast initially, but then turns to the northeast as well. Historically, tritium has been observed as far northeast as Abbott Ditch. Carbon-14 is known to be moving as far as the springs feeding Trout Lake. Although the concentrations of tritium in Trout Lake are above the minimum detectable concentration, they are still below the applicable IEMA maximum permissible concentration (MPC) by a factor of 600. The tritium concentration in water moving off the buffer zone is below the applicable MPC by a factor of 15,000. Radionuclide concentrations in public and private drinking water supplies remain at background levels. Overall, the concentrations of tritium are trending downward.

Data from air sampling indicates only background radioactivity. Direct radiation measurements are typical of background levels in northern Illinois. Vegetation samples contained radionuclides attributable to fallout from weapons testing several decades ago. Sediment samples do not contain radionuclides from LLRW operations.

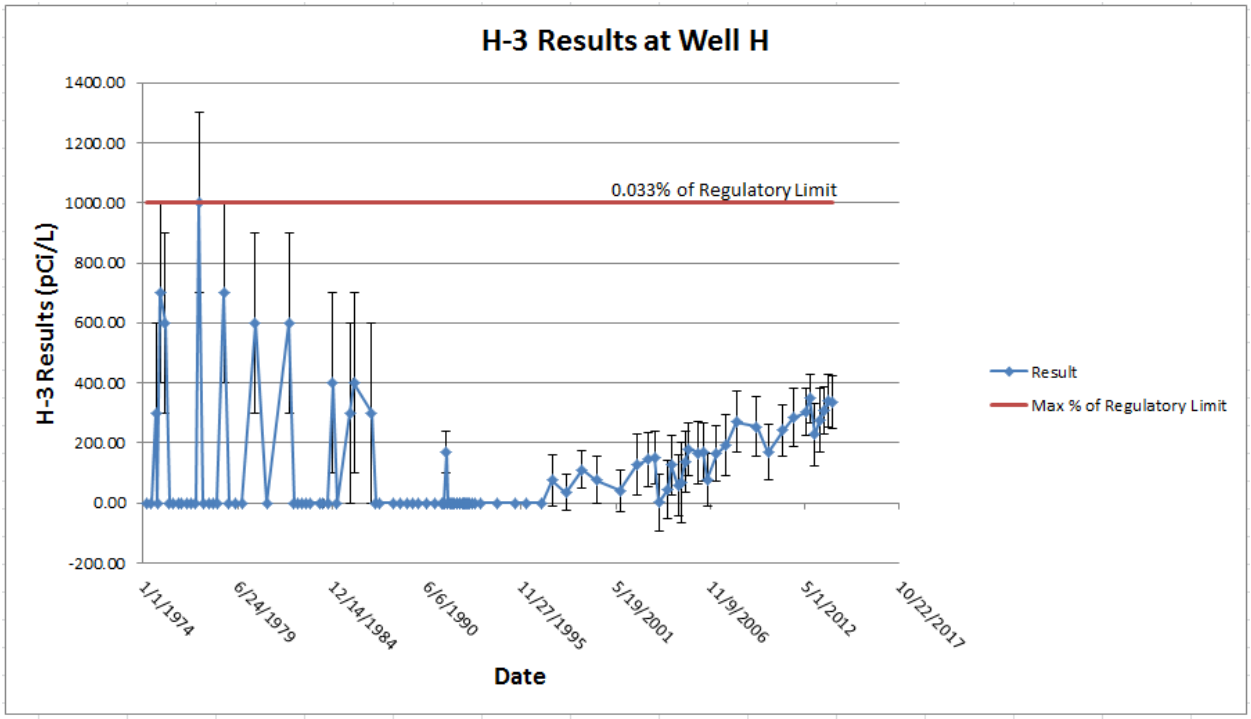
Appendix A. Graphical Representations of On-Site Tritium (H-3) Water Sample Results from 1988 through 2013



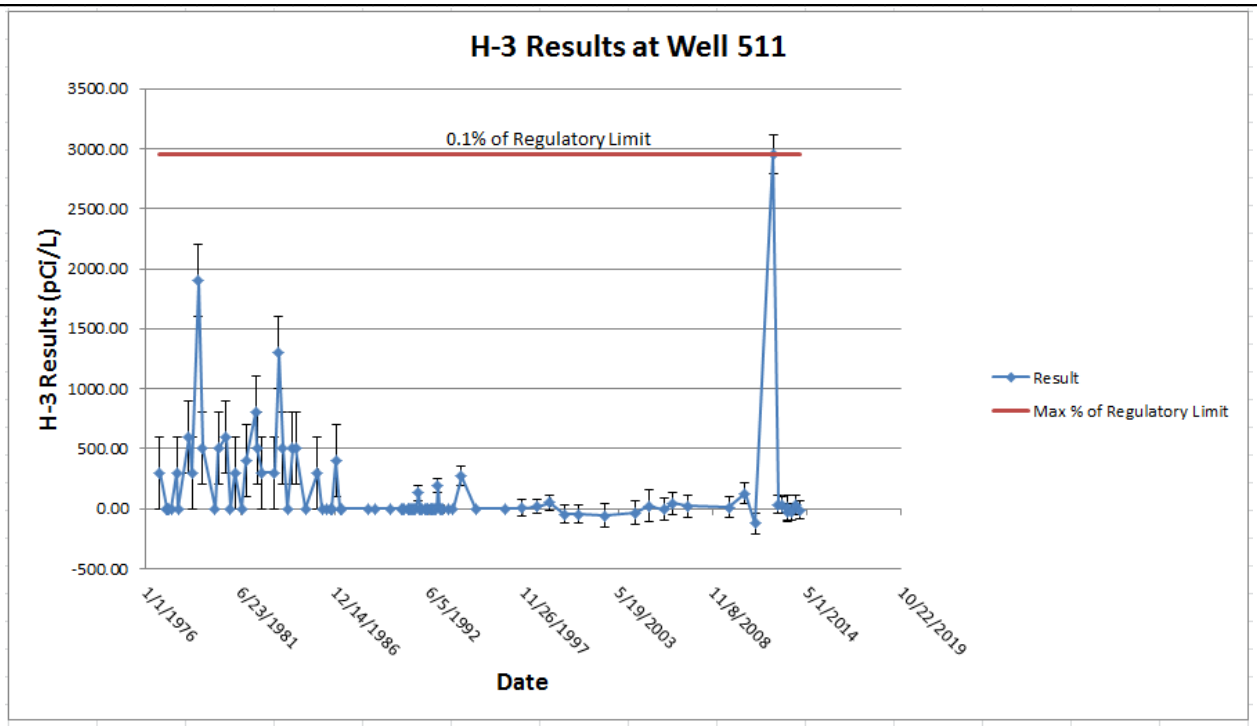
Chem Well 150 is located on the western edge of the Buffer Zone, close to the Chemical Waste site.



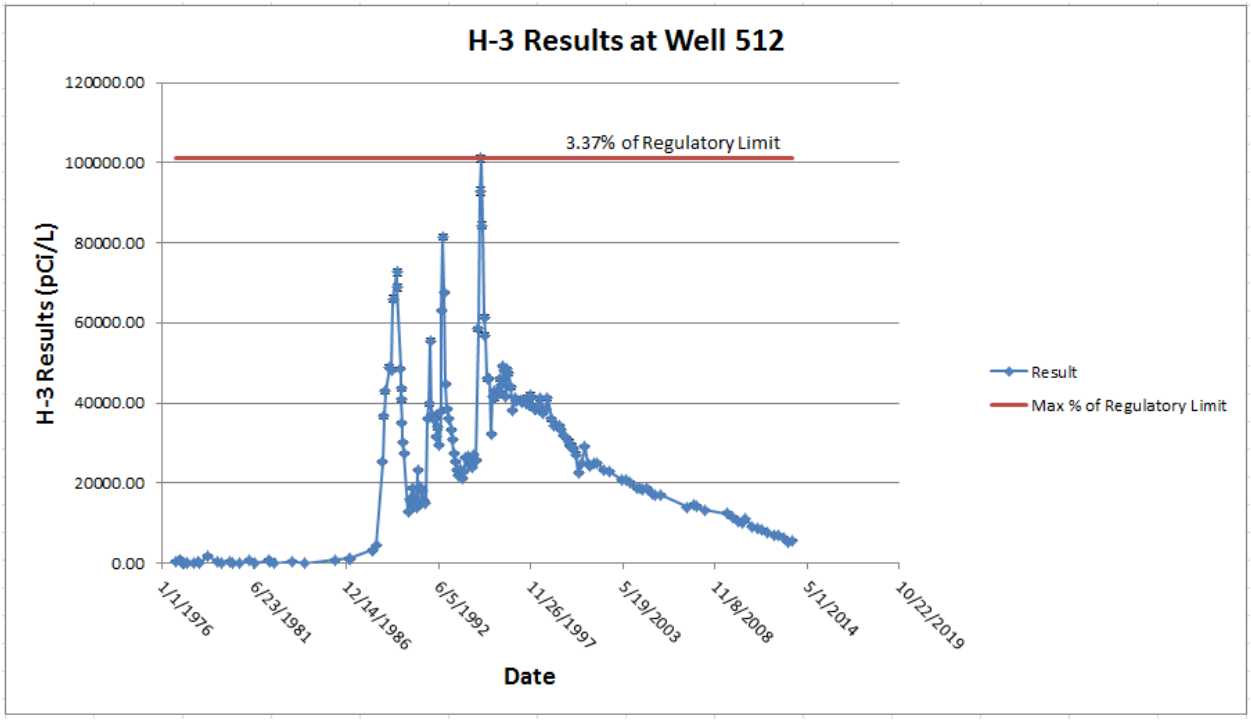
The lunchroom is not a well, but an on-site location fed by a local water supply.



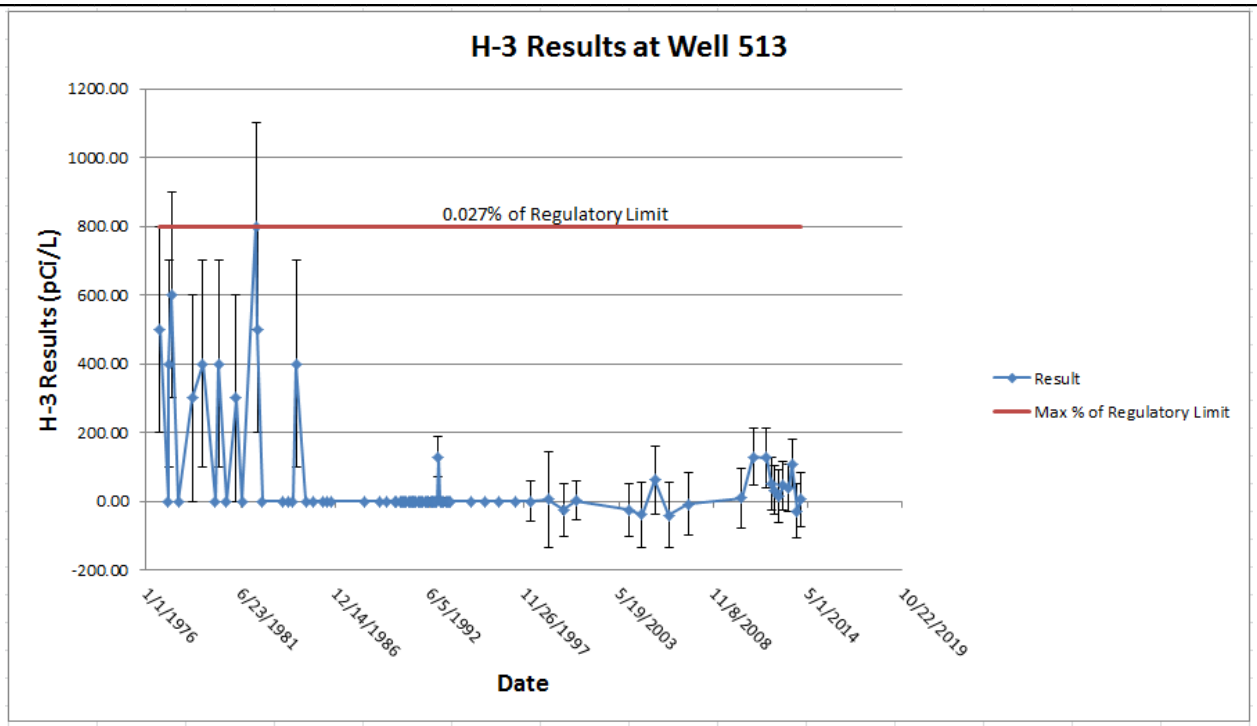
Well H is immediately to the south of the LLRW site.



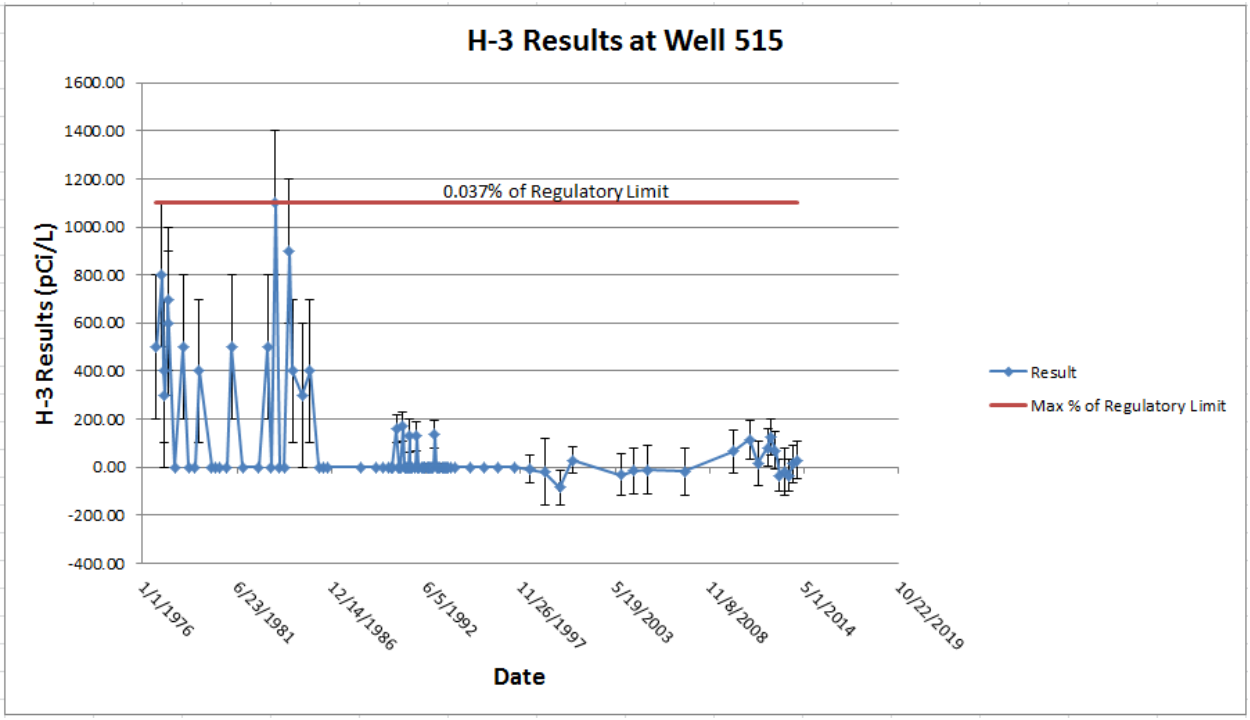
Well 511 is located immediately to the west of the LLRW site.



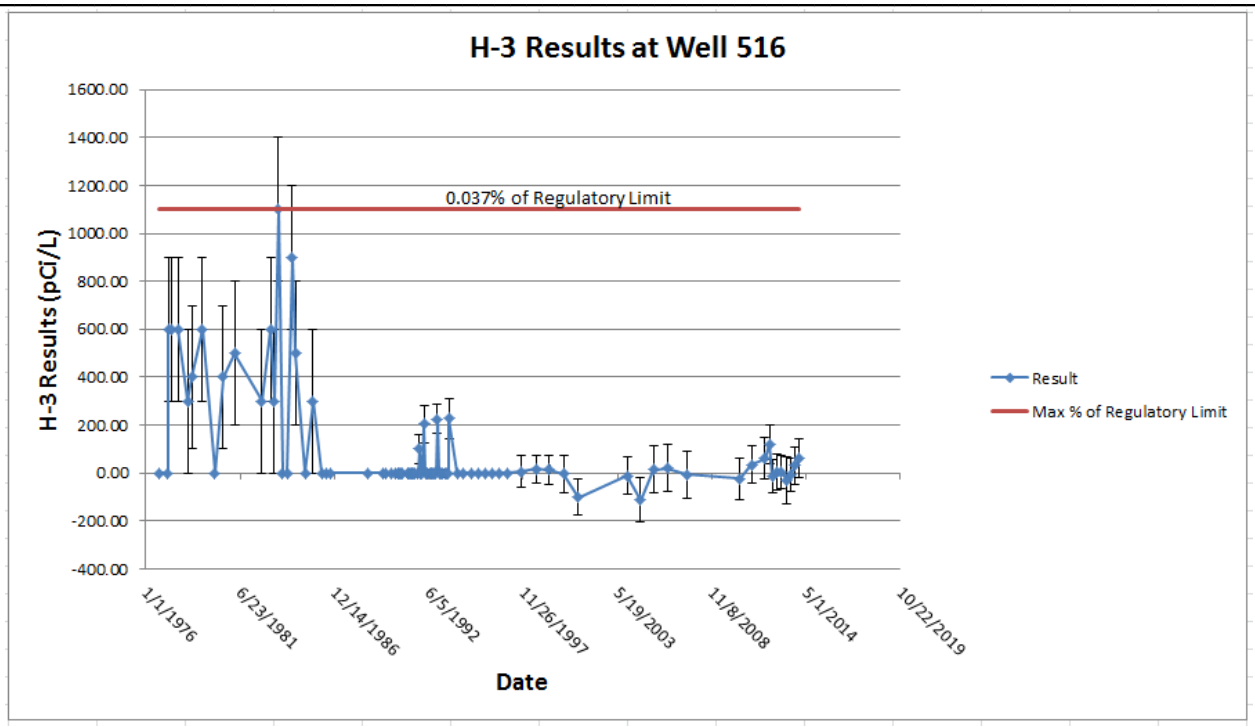
Well 512 is located south and east of the LLRW site, and is in the Southeast Pathway.



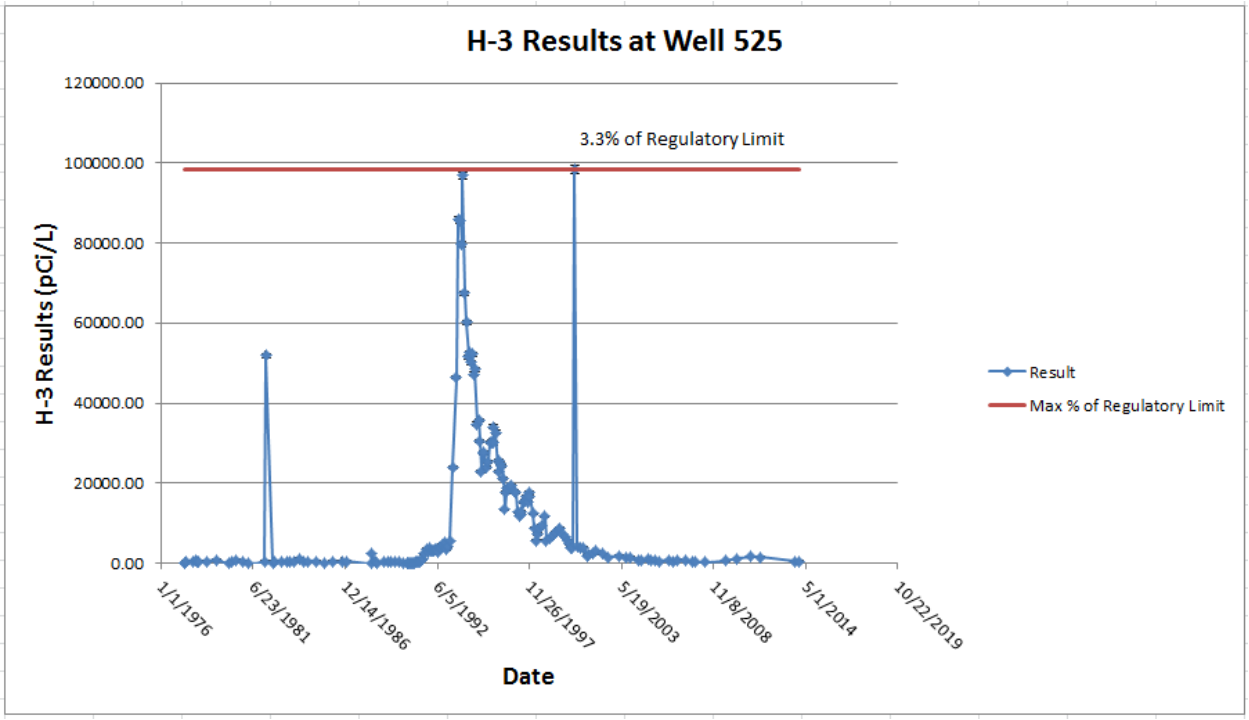
Well 513 is located near the northwest corner of the LLRW site.



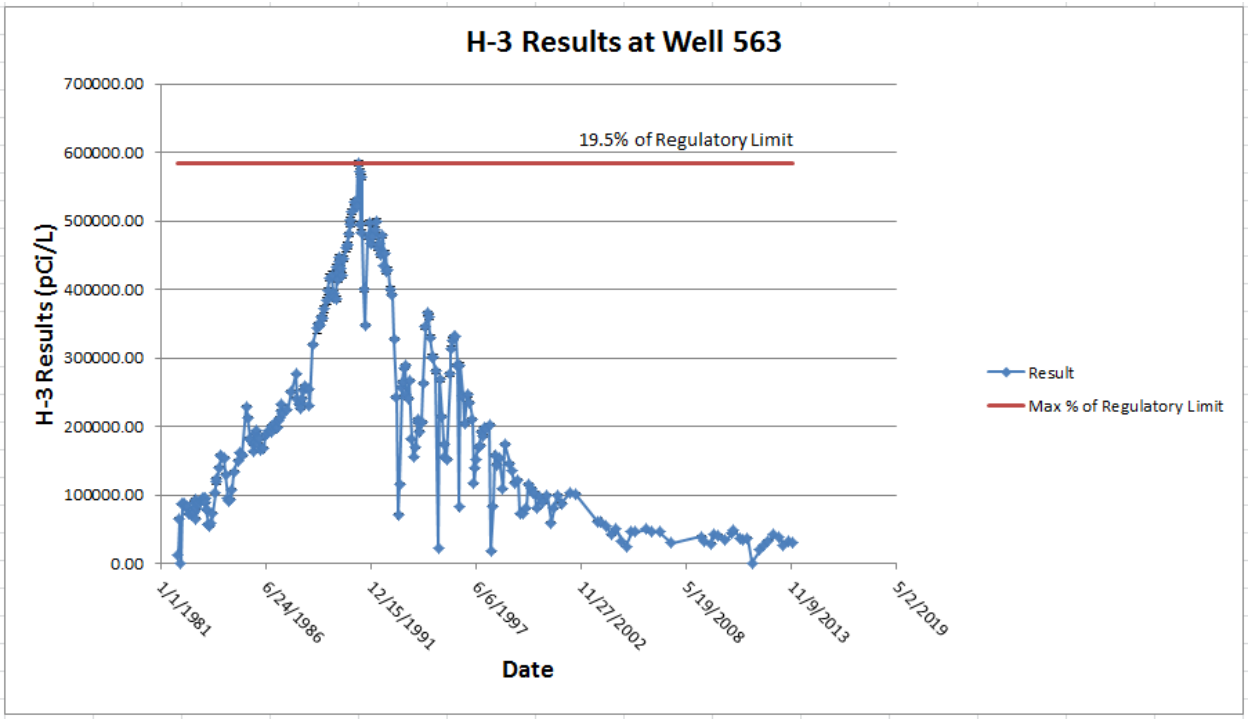
Well 515 is located along the north edge of the LLRW site.



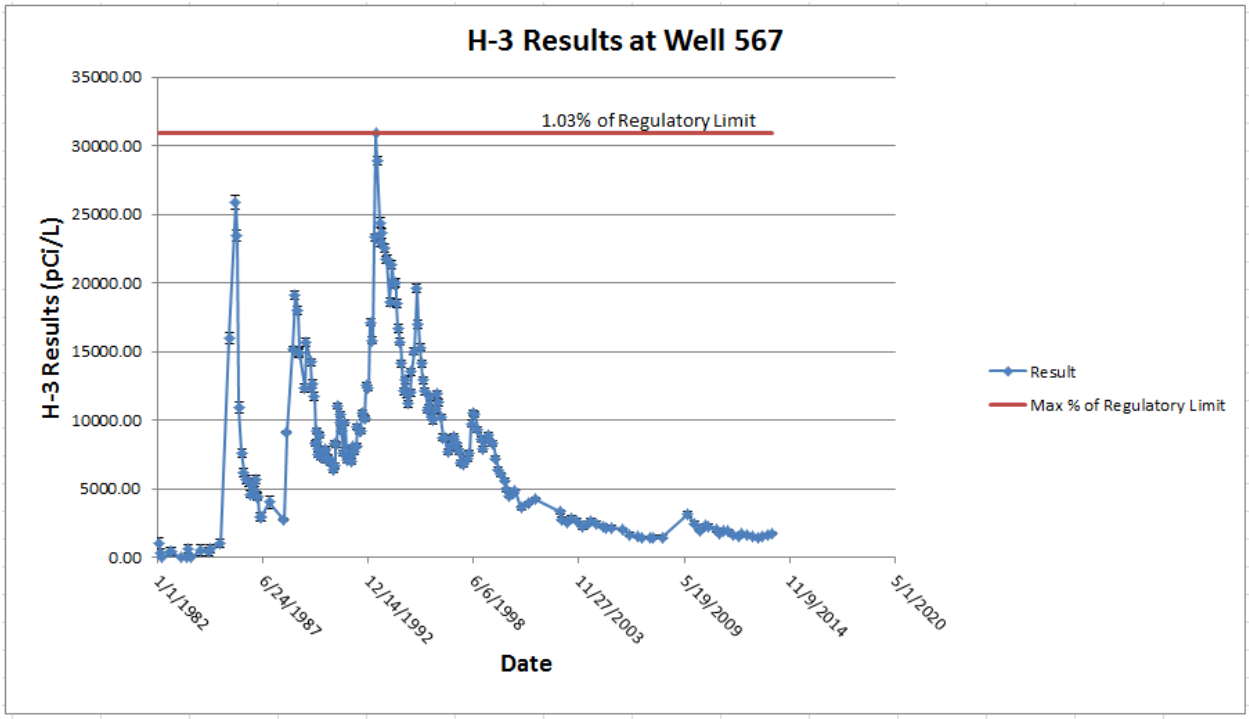
Well 516 is located along the north edge of the LLRW site.



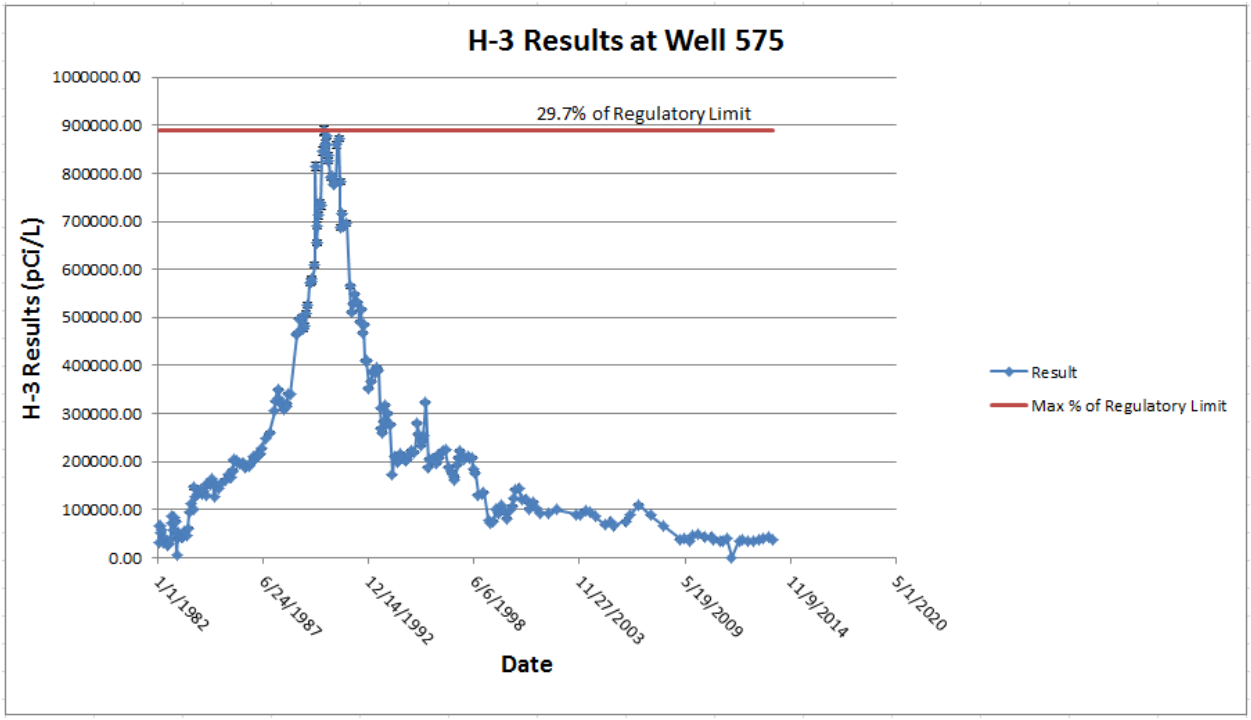
Well 525 is located south and east of the LLRW site, and is in the Southeast Pathway.



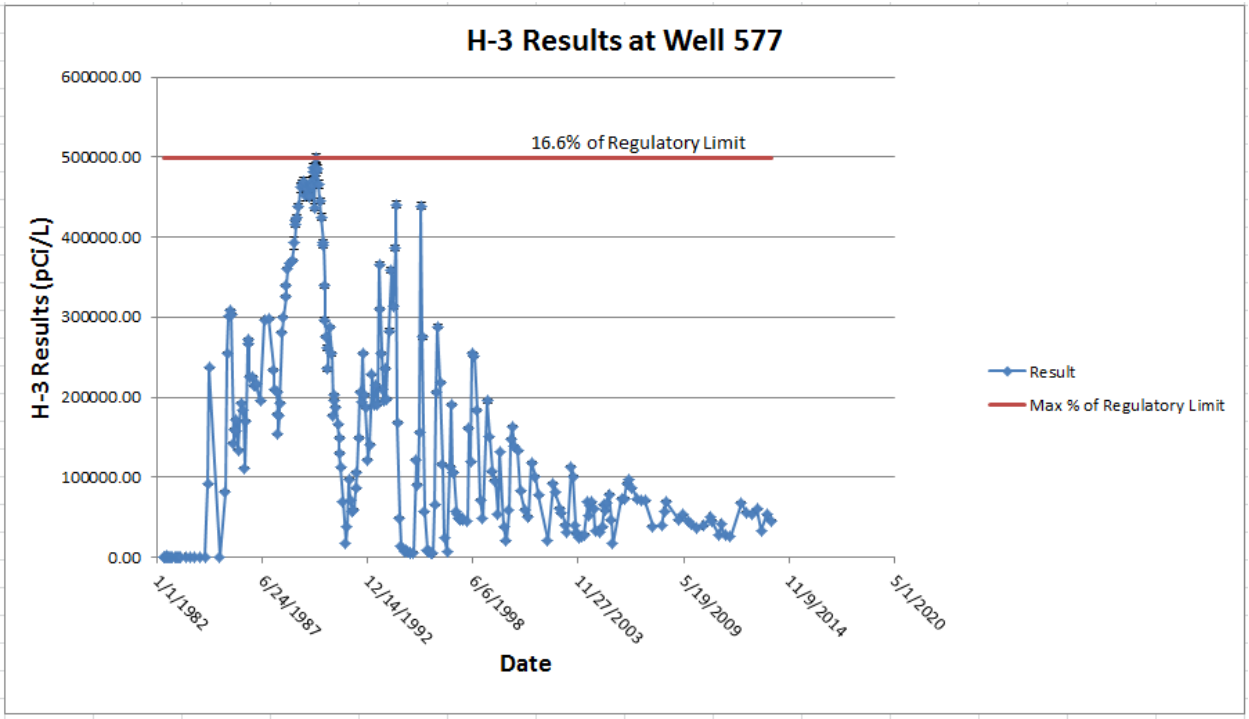
Well 563 is located east of the LLRW site, and is in the Northeast Pathway.



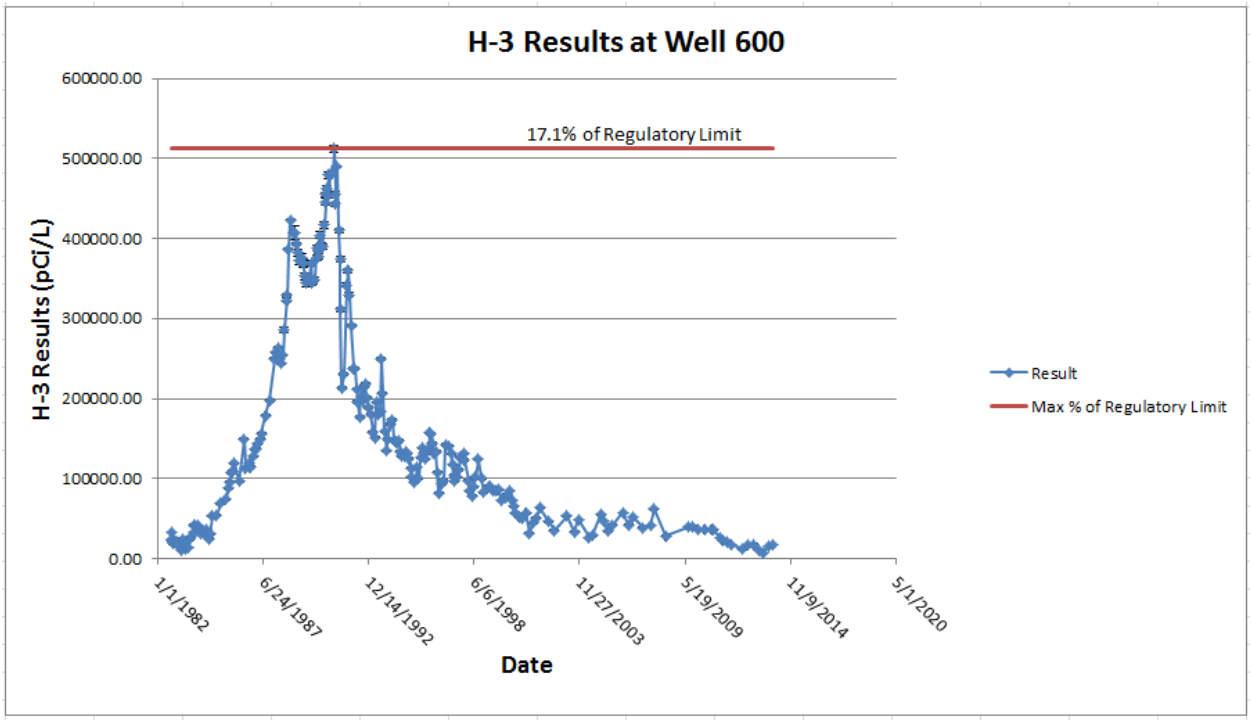
Well 567 is located east of the LLRW site, and is in the Southeast Pathway.



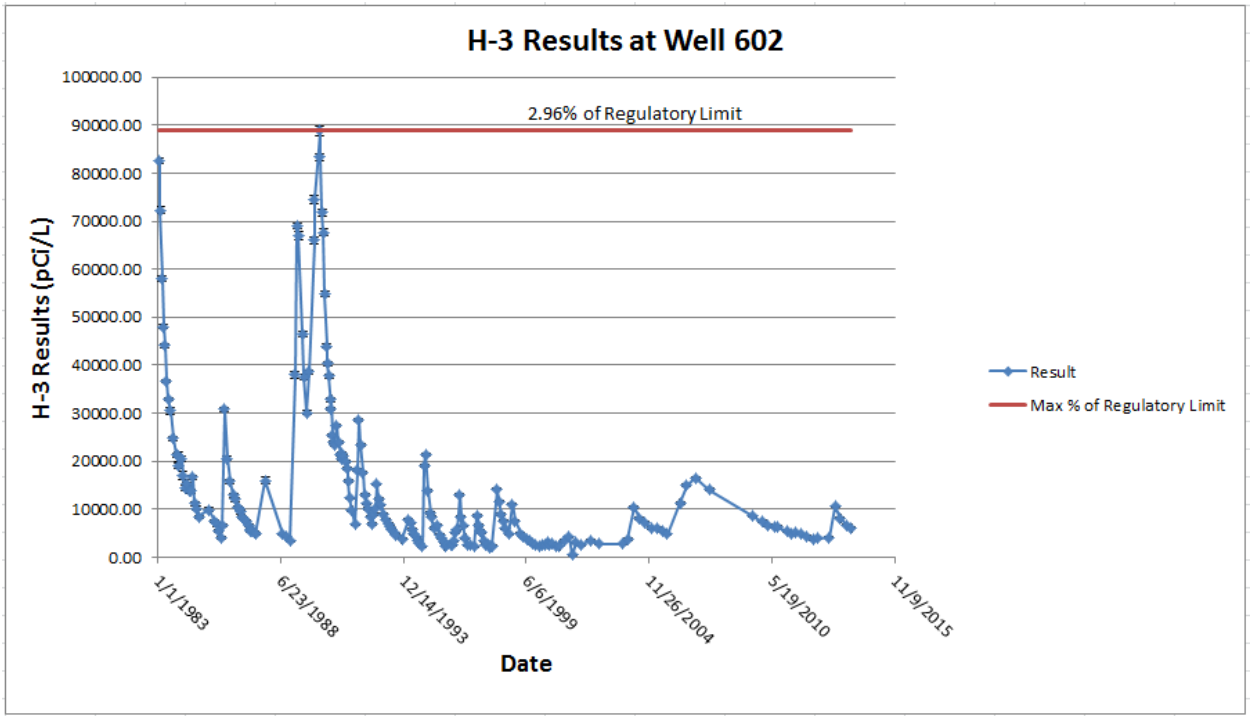
Well 575 is located east of the LLRW site, and is in the Northeast Pathway.



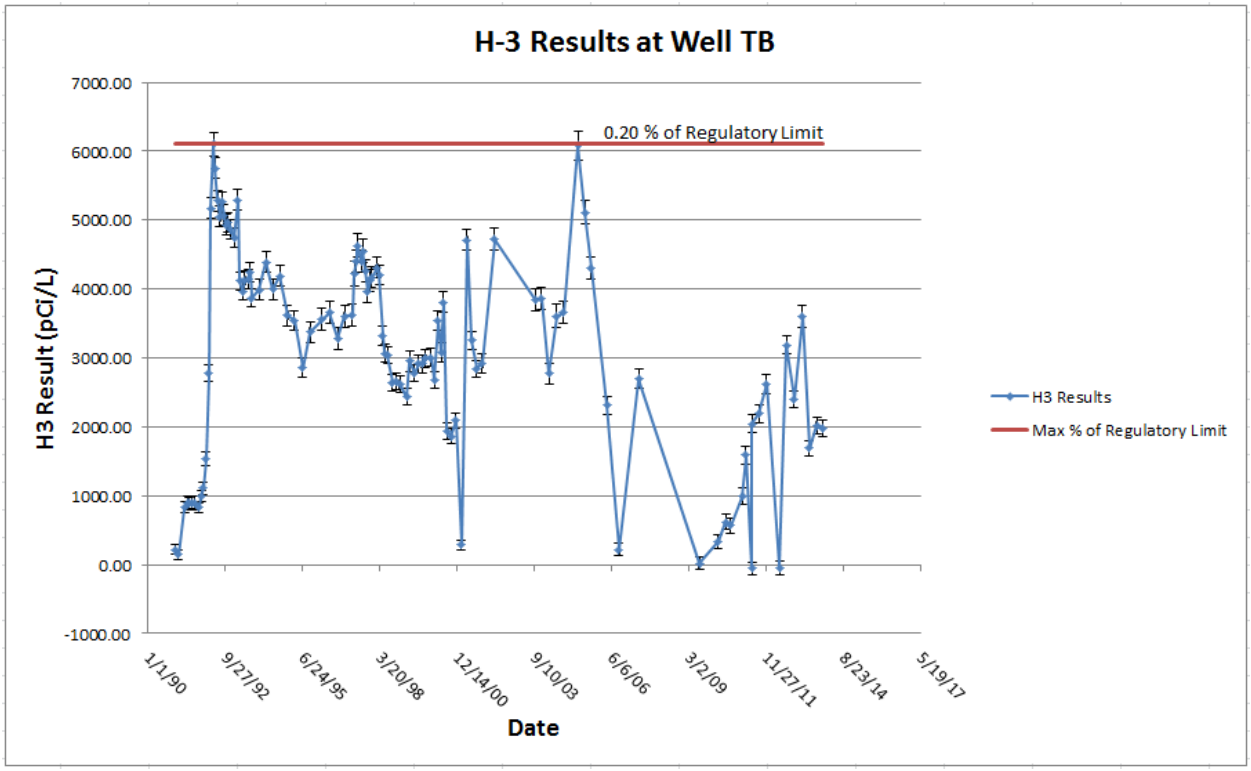
Well 577 is located east of the LLRW site, and is in the Northeast Pathway.



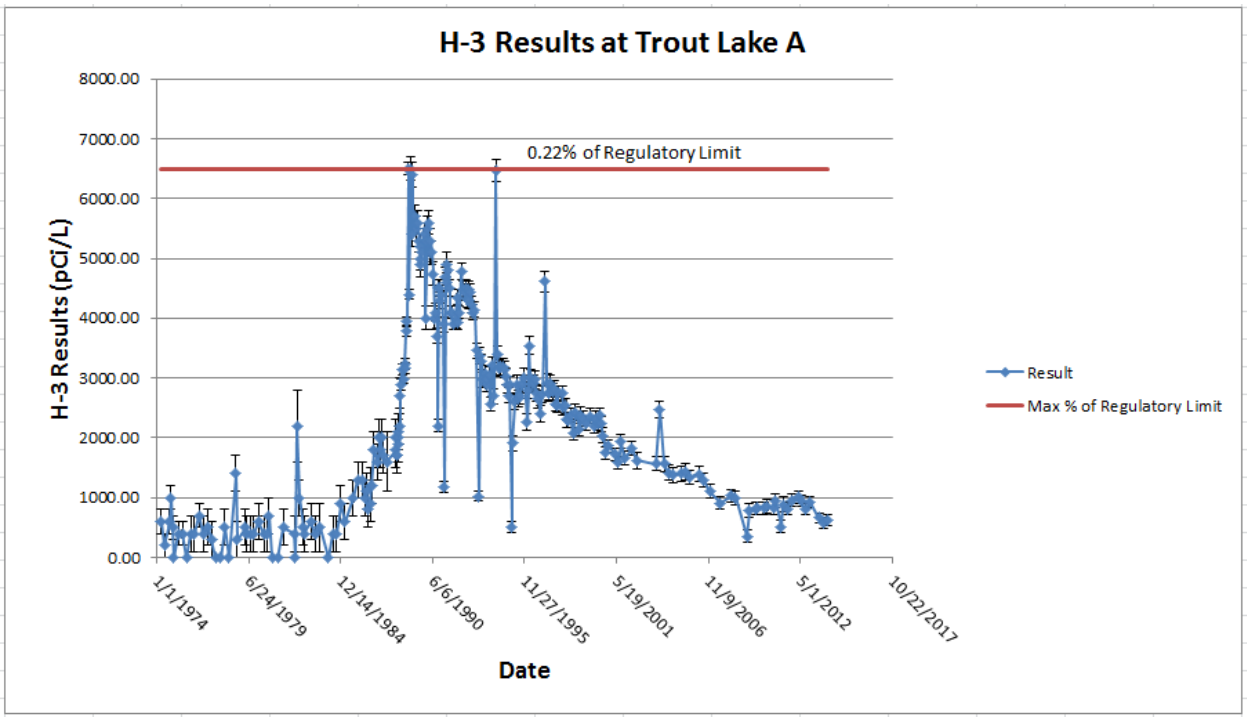
Well 600 is located east of the LLRW site and is in the Northeast Pathway.



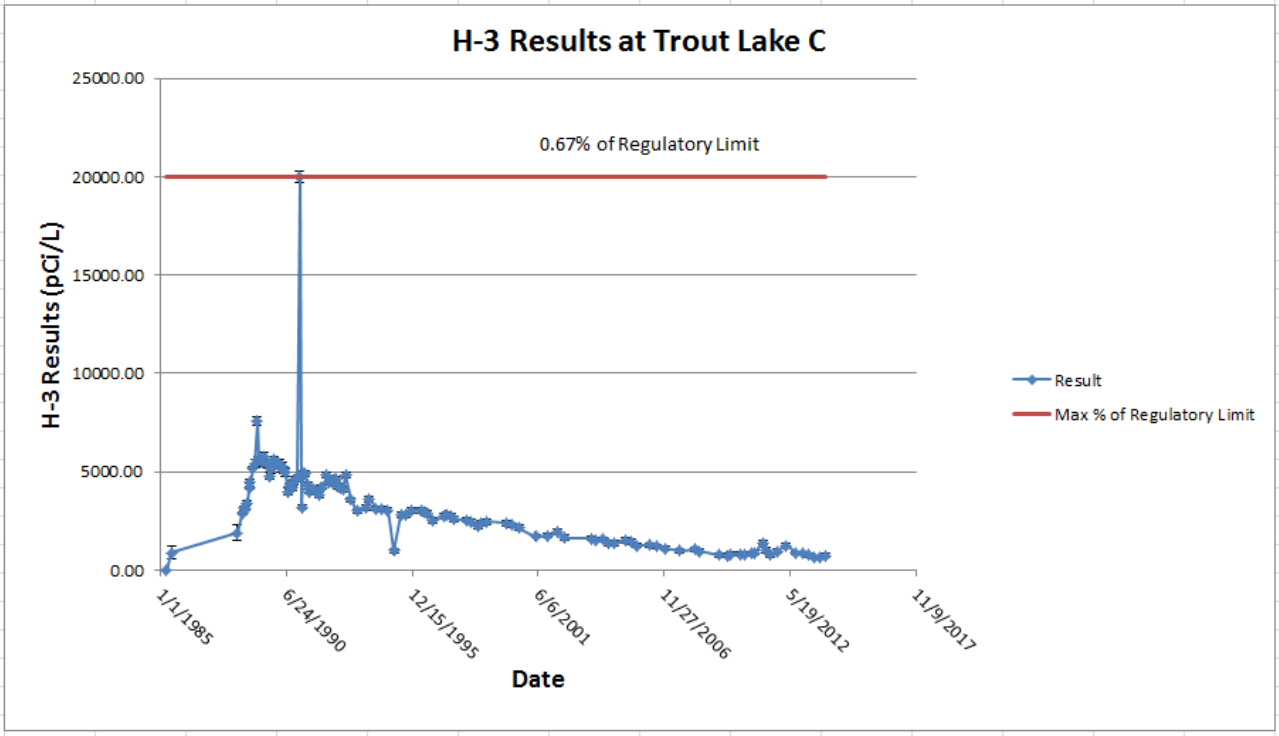
Well 602 is located east of the LLRW site, and is in the Southeast Pathway.



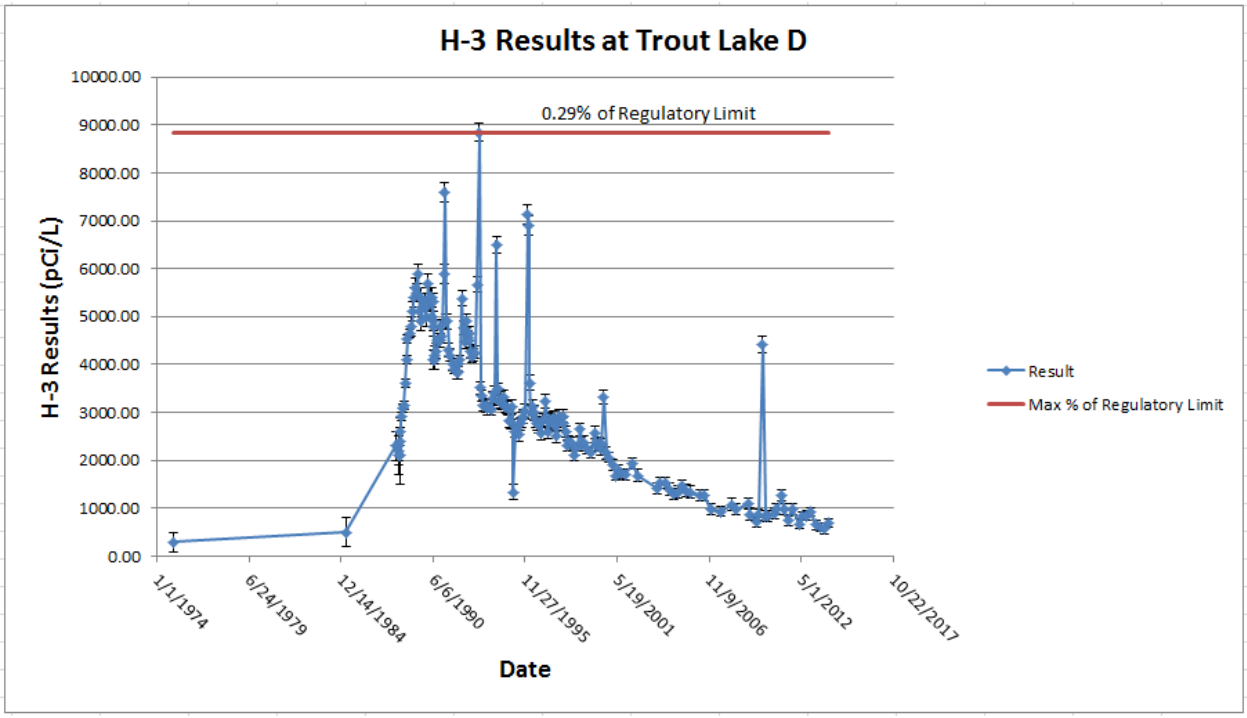
Well TB is located south of the LLRW site, and is in the Southeast Pathway.



Trout Lake A is located on the north western edge of Trout Lake.

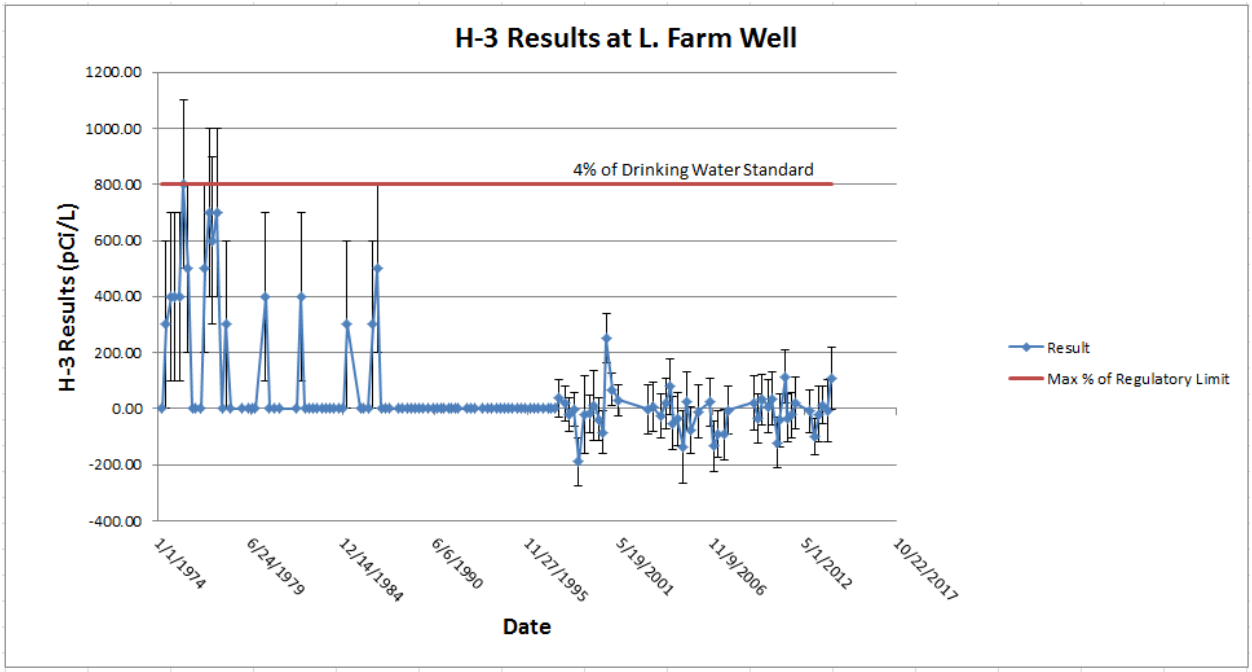


Trout Lake C is located approximately in the middle of Trout Lake.

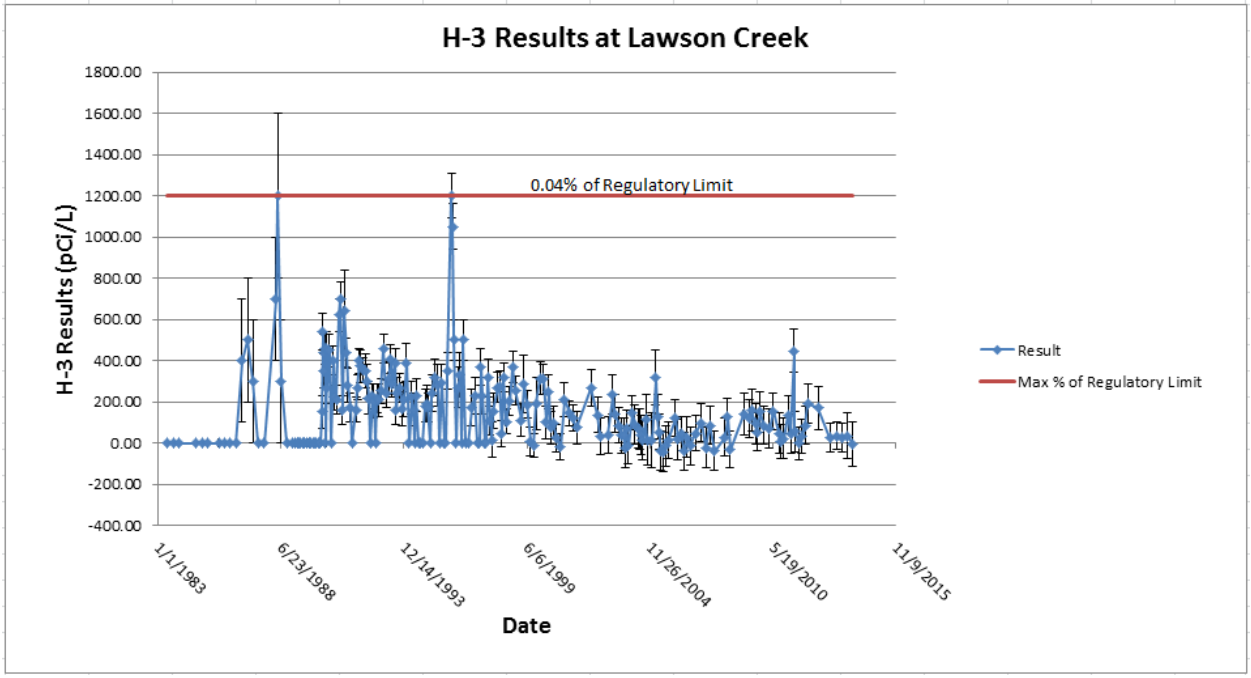


Trout Lake D is located on the eastern end of Trout Lake.

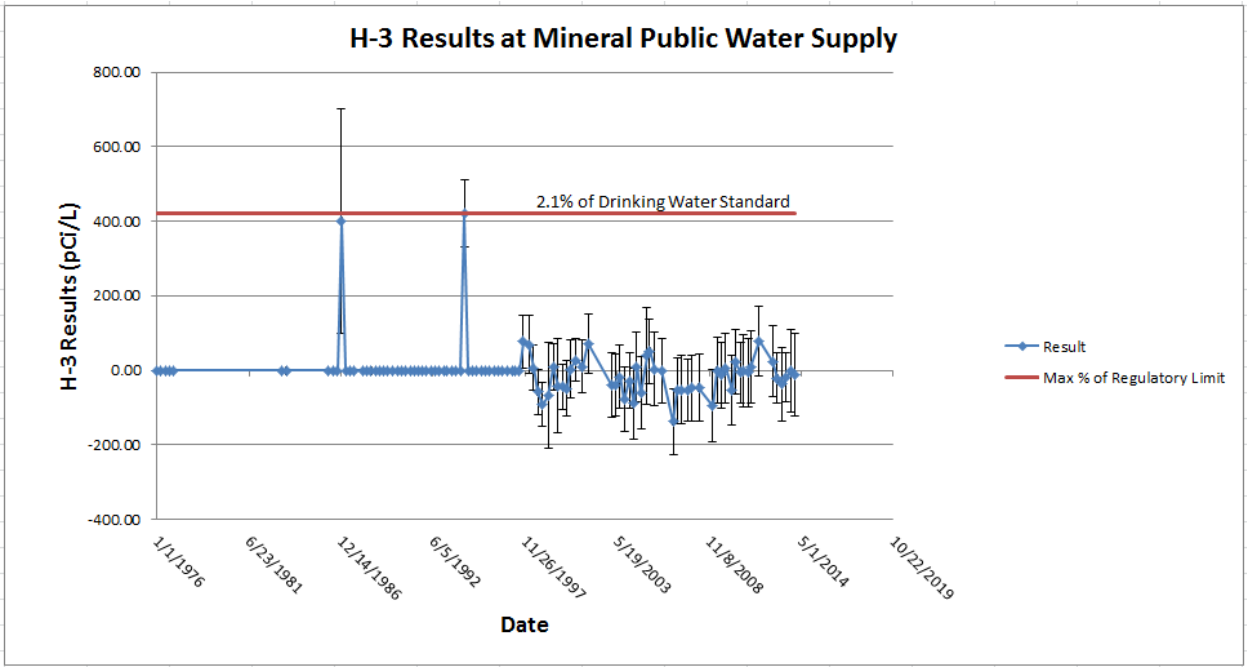
Appendix B. Graphical Representations of Off-Site Tritium (H-3) Water Sample Results from 1988 through 2013



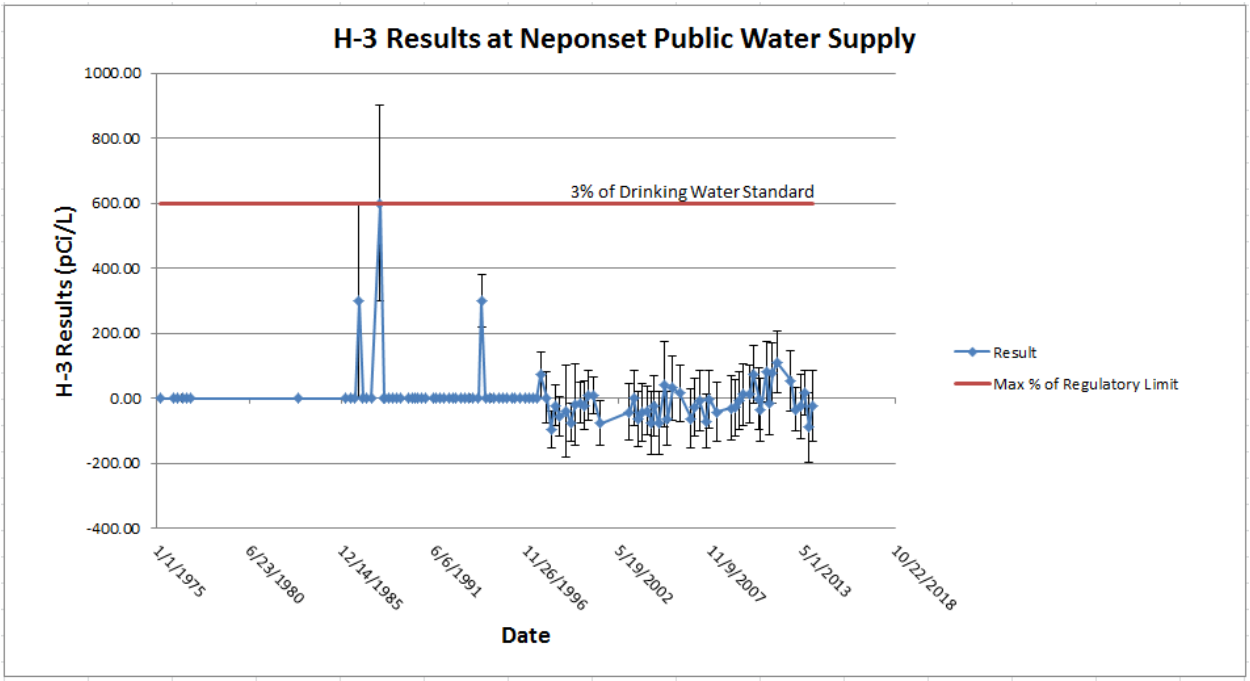
L. Farm Well is located north and slightly west of the LLRW site.



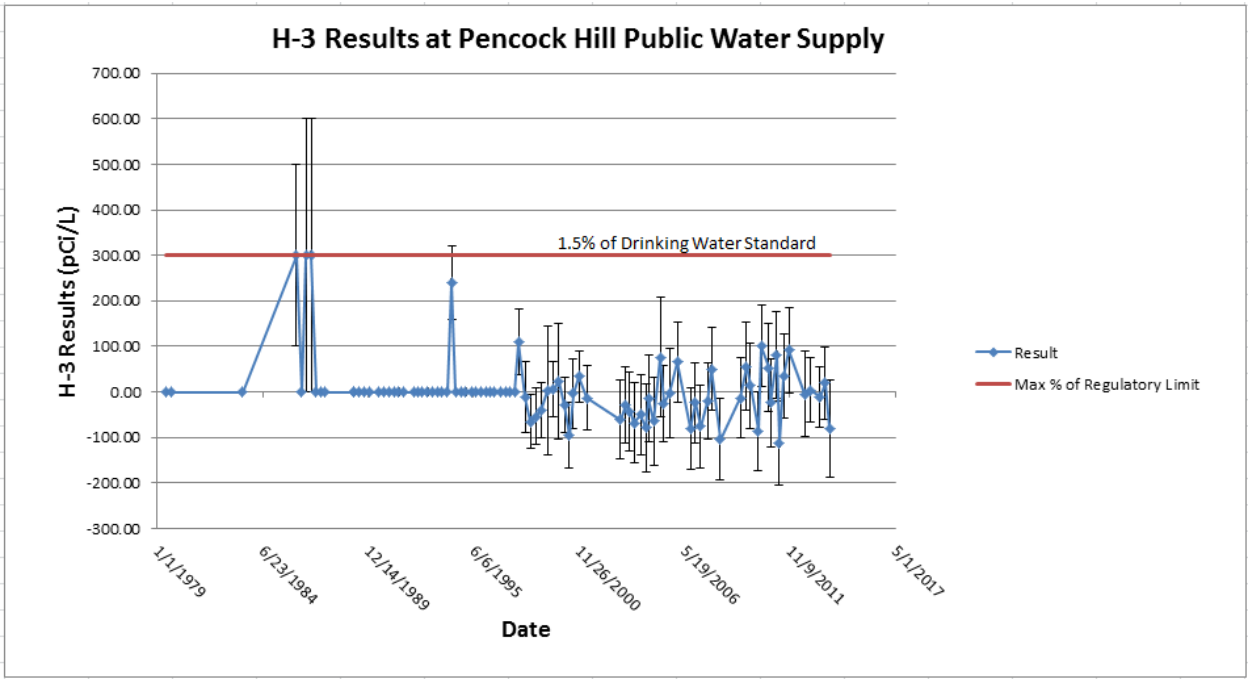
The Lawson Creek sampling point is located east and north of the LLRW site.



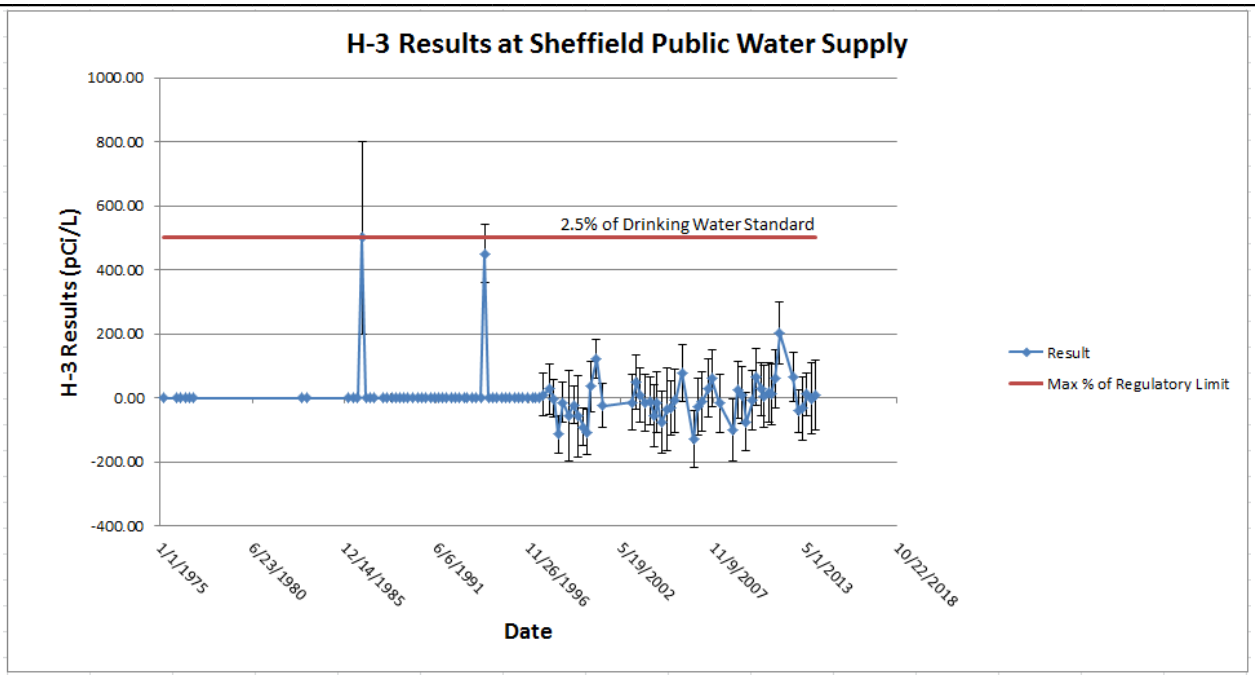
The Mineral PWS sampling point is located northeast of the LLRW site.



The Neponset PWS sampling point is located south of the LLRW site.



The Pencock Hill PWS sample location is south of the LLRW site.



The Sheffield PWS sampling location is northwest of the LLRW site.

Appendix C. Graphical Representations of On-Site Tritium (H-3) Water Sample Results from 1988 through 2013

Figure C-1. Sheffield On-Site Sampling Locations and Buffer Zone Outline

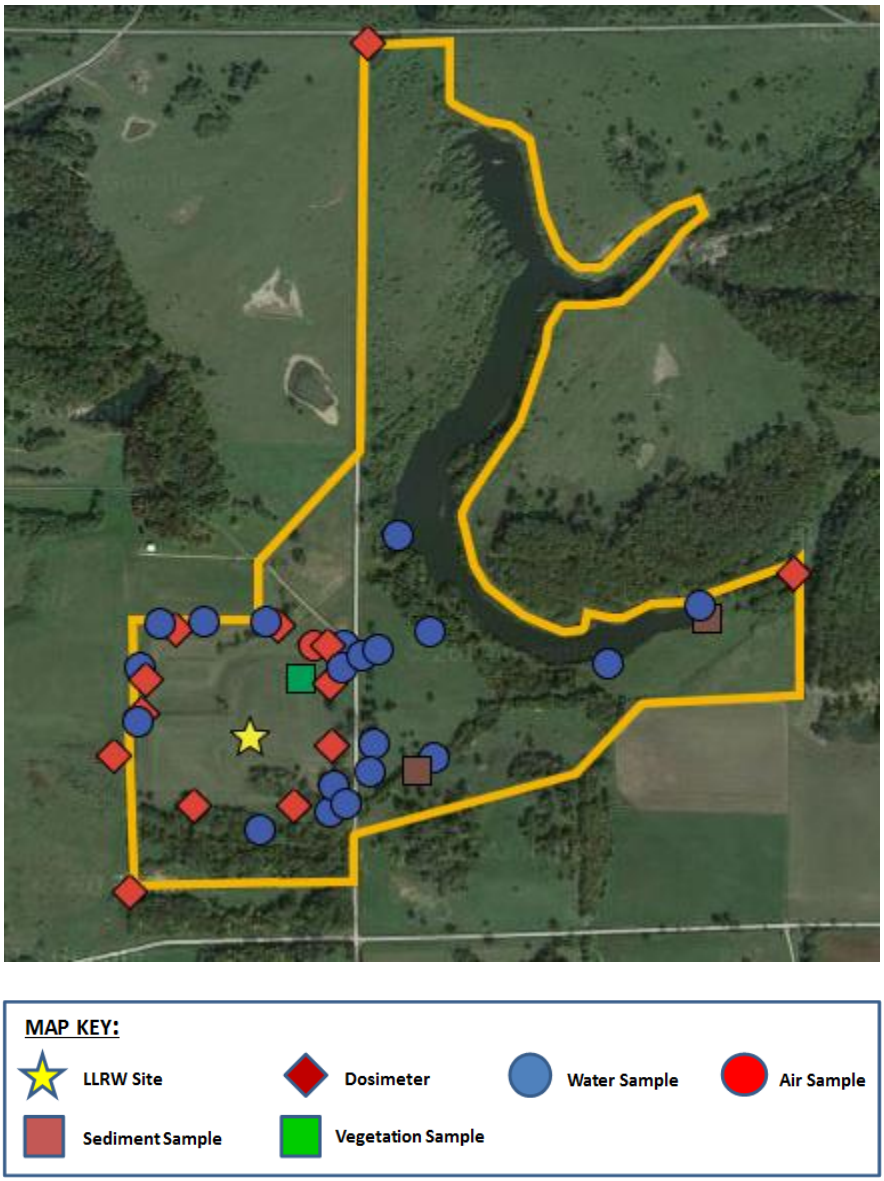


Figure C-2. Sheffield On-Site Sampling Locations

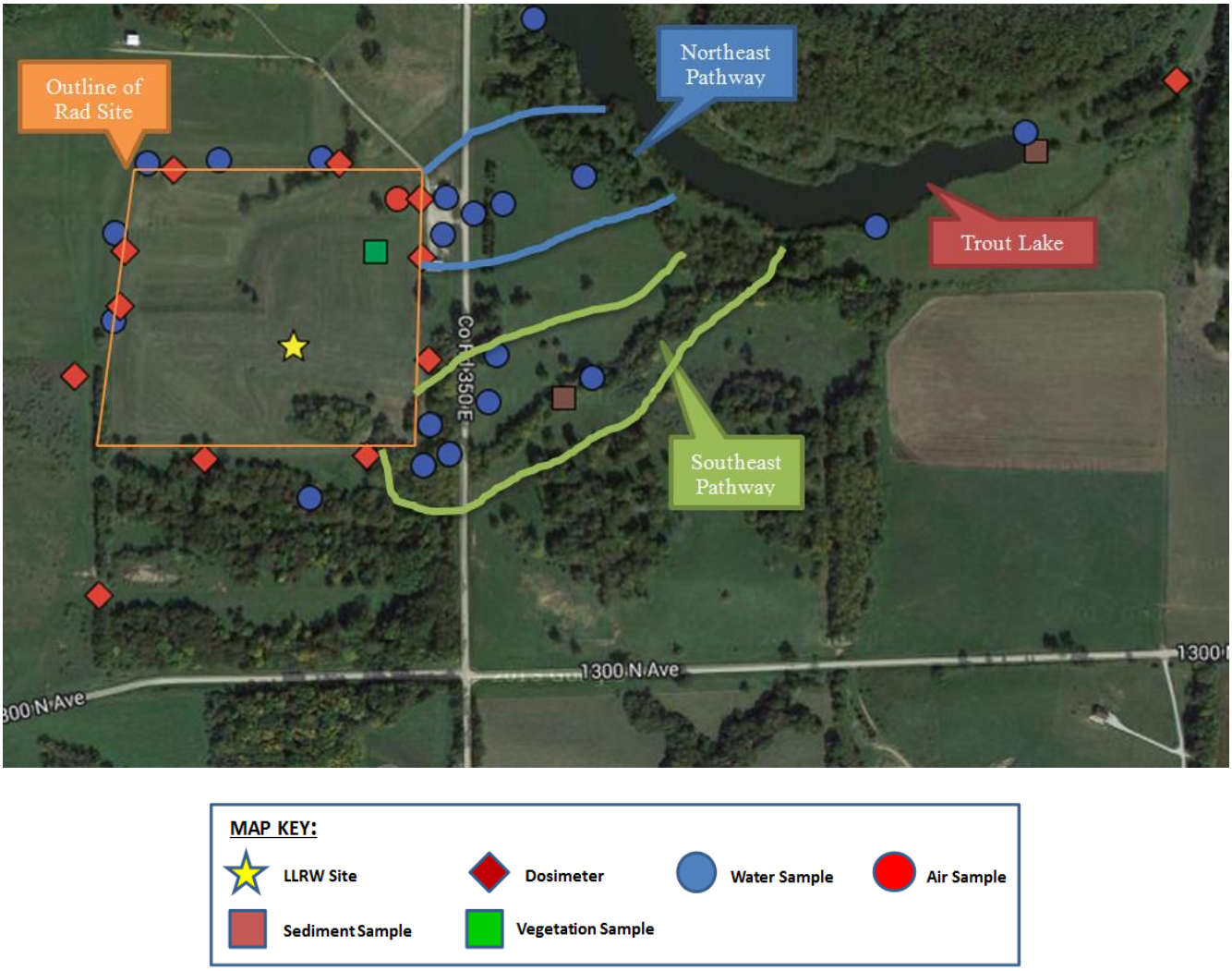


Figure C-3. Sheffield Off-Site and Surrounding Sampling Locations